AN ACCOUNT

OF

EXPERIMENTS FOR DETERMINING

THE

VARIATION IN THE LENGTH OF THE PENDULUM VIBRATING SECONDS,

AT THE

PRINCIPAL STATIONS OF THE TRIGONOMETRICAL SURVEY OF GREAT BRITAIN.

BY CAPT. HENRY KATER, F. R. S.

FROM

THE PHILOSOPHICAL TRANSACTIONS.

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"possession of this house, and for determining the variations "in length of the said pendulum, at the principal stations of "the Trigonometrical Survey extended through Great Bri- "tain; and also for comparing the said standard measures, "with the ten millionth part of the quadrant of the meridian, "now used as the basis of linear measure on (*a part of*) the "continent of Europe."

In consequence of His Royal Highness's compliance with the prayer of this Address, an application was made by His Majesty's Ministers to the Right Honourable Sir JOSEPH BANKS, requesting that the Royal Society would be pleased to afford all the assistance in their power for the accomplishment of the objects therein mentioned; and a Committee was appointed for that purpose, of which I was named a member.

The length of the pendulum vibrating seconds in the latitude of London, and that of the French mêtre having been determined, it remained to ascertain the length of the pendulum at the principal stations of the Trigonometrical Survey.

This work the Royal Society did me the honour to request I would undertake; and the ready compliance of Government with every requisition I made through Sir JOSEPH BANKS, for that assistance without which my success might have been doubtful, led me to devote with pleasure my time and labour to this highly interesting enquiry.

The instruments with which I provided myself were, a transit by DOLLAND, of three feet and a half in length, constructed on the same principle as the transit at the Royal Observatory at Greenwich, so as admirably to combine lightness with strength.

A repeating circle of one foot diameter by TROUGHTON,

A clock and a box chronometer by ARNOLD, for the loan of which I was indebted to HENRY BROWNE, Esq. F.R.S. and

An invariable pendulum with its support, a description of which will be given hereafter. To these was added, a chest of tools of various kinds.

A small light waggon was constructed at the Royal Arsenal at Woolwich for the conveyance of these instruments, and a party consisting of a non-commissioned officer, two gunners, (one a carpenter), and two drivers with four horses of the Royal Artillery, was placed under my orders: a bell tent, and two others of a smaller description, were issued, which I found particularly useful.

His Royal Highness the Commander in Chief was pleased to direct that I should receive such military assistance as might be necessary for the safety of the instruments at the different stations, and for the use of barracks, where I might find them suited to my experiments; and an application being also made to the Admiralty for a vessel to convey me to the Shetland Islands, His Majesty's sloop of war the Cherokee, commanded by Capt. T. SMITH, was ordered to receive me at Leith, and to bring me back to Scotland.

Thus liberally provided with all that could tend to facilitate the success of my undertaking, I left London on the 24th June with Lieut. FRANKS of the Royal Navy, a gentleman whose fondness for science induced him to accompany me, and arrived at Leith on the evening of the 28th.

Here on enquiry I found that the Cherokee had not been heard of for some time, but the Admiralty having ordered that any requisition I made should be complied with,

and His Majesty's sloop the Nimrod, commanded by Capt. DALLING, being in the harbour, she was directed to prepare immediately for sea, and on the 1st July, her provisions being completed, I embarked for Unst.

Having put into Lerwick for two days, I availed myself of the opportunity to present a letter of introduction to Dr. EDMONDSTONE, and to obtain one from him to his brother THOMAS EDMONDSTONE, Esq. of Unst, to whose hospitality I was aware I must be indebted during my stay on that Island.

On the 9th July we arrived at Unst, having been joined on the voyage by the Cherokee, bearing an order from the Admiral commanding at Leith to relieve the Nimrod. To both Capt. DALLING and Capt. SMITH I feel myself much indebted, not only for their judicious arrangements for the safety of the instruments, but also for the personal kindness and attention I experienced from them.

At Unst, I was welcomed on the beach by Mr. EDMONDSTONE, who had received notice from his brother of my intended visit; and I immediately proceeded to examine the buildings which surrounded this gentleman's house, to select a place proper for my experiments. I at length chose the shell of an unfinished cottage nearly adjoining to the cow-house, in which the preceding summer M. BIOT had made his observations on the pendulum when he visited Shetland on the part of the Institute of France. One wall of this cottage, upwards of three feet thick, was ancient, though the rest of the building was modern, and it seemed to promise sufficient stability for my purpose.

It is now necessary to give a description of the apparatus I employed.

The pendulum was composed of a bar of plate brass 1,6 inches wide, and rather less than the eighth of an inch thick. These dimensions were chosen that the pendulum and the thermometer placed near it, might be affected with equal readiness by any change of temperature. A flat circular weight nicely turned, and pierced in the direction of its diameter to receive the bar, was slid upon it, and fastened with screws and rivets at such a distance from the knife edge which served as the point of suspension, and which will presently be described, as that the pendulum made two vibrations less than the pendulum of the clock, in eight or nine minutes. The inside of the weight having been previously tinned, it was exposed to a sufficient degree of heat to solder it to the bar.

That part of the bar which was below the weight, was reduced to the width of 0,7 inch, and covered with black varnish, in order to enable me the better to observe its coincidence with the pendulum of the clock, in the manner which has been fully described in the Philosophical Transactions for 1818, in an " Account of Experiments on the length of the Pendulum vibrating seconds in the latitude of London." With the contents of this Paper I shall suppose a previous acquaintance, as an occasional reference to it will save much repetition.

To the top of the bar, a strong cross piece of brass was firmly rivetted and soldered, and a triangular hole having been made in the bar, a knife edge was passed through it, and a perfect contact between the back of the knife edge and the cross piece was insured by grinding them together. It was then secured in its place by two screws, the heads of

which were sunk in the cross piece, and having been warmed, were dipped in pitch to prevent the possibility of their being loosened by the motion of the waggon.

The knife edge was made of wootz, precisely in the same manner as described in the experiments on the length of the seconds pendulum, its ultimate angle being about 120°. The length of the bar from the knife edge to the extremity was about five feet, and it terminated in an obtuse angle, serving to indicate the arc of vibration. The weight of the whole pendulum was 15 lb. 2 oz.

The perfect immobility of the point of suspension being of the utmost consequence, every precaution was taken by the arrangement of the form, and by the weight of the frame destined to carry the pendulum, to oppose the lateral force which might result from its vibrations.

The frame was of cast iron; the horizontal part was 19 inches long, 17 wide, and half an inch thick. The back, three inches in width, at right angles to the length was pierced with three equi-distant holes in the horizontal direction, to receive very large screws about five inches long, with coarse threads destined to attach the frame to pickets of wood driven into a wall. Two brackets were firmly screwed to the under part of the horizontal frame; these brackets were bevilled so as to spread at the bottom to the width of three feet, thereby opposing more effectually any disposition to lateral motion. In the lower extremities of the brackets, two holes were made for screws similar to those above mentioned. The weight of the frame was 87 lb.

A bell metal support, furnished with agate planes on which the knife edge of the pendulum was to rest, varied but little

from that described in the Philosophical Transactions before referred to. It was contrived in such a manner as to be attached to the iron frame by three screws, and was levelled by placing thin sheets of lead between it and the frame, a method which was preferred from its promising a great degree of firmness.

An arc divided into degrees and tenths for ascertaining the extent of the vibrations of the pendulum, was attached to a piece of wood which fitted into the opening of the door of the clock case.

Expansion of the pendulum.

When the bar of the pendulum was prepared, previous to the weight being soldered to it, its expansion was determined in the same manner as is described in the Philosophical Transactions before referred to. The results were as follow:

Distance between the lines on the Bar 39,54 inches.				
Highest Temp.	Lowest Temp.	Diff. of Temp.	Div. of Microm.	Expansion in parts of the length for each degree.
° 125,0	° 56,3	° 68,7	648	,00001022
125,0	99,0	26,0	245	,00001021
99,0	73,8	25,2	220	,00000946
73,8	63,0	10,5	91	,00000938
			Mean	,00000982

Hence the expansion of the pendulum appears to be ,00000982 parts of its length for each degree of the thermometer; and the corresponding correction to be applied to the number of vibrations in 24 hours for such change of temperature will be 0,423.

Operations at Unst.

I have remarked, that I selected for my experiments at Unst, an unfinished cottage, one of the walls of which was three feet thick. This was composed of irregular masses of serpentine, which I feared might be loosened by driving in the pickets to which the iron frame was to be screwed. Happily, however, I found the pickets act as wedges, and secure the stones more firmly in their places. The pickets driven into the wall were of oak, and were upwards of three inches in diameter, and more than a foot in length. To these the iron frame was firmly attached by its five screws, and on the evening of the 10th of July, I had the satisfaction of finding it as securely fixed as I could possibly desire.

Two pieces of deal plank two inches and a half thick, were next fastened by long nails to the wall. To these the clock case was screwed at such a distance beneath the iron frame, as that the end of the brass pendulum might reach a little below the centre of the pendulum of the clock, and the clock was then put *in beat*, by moving the bottom of the case to the right or left, and when properly adjusted, the screws were tightened. The bell metal support was next put in its place and carefully levelled, and the pendulum lodged in the Ys elevated for that purpose.

The triangular stand carrying the telescope, described in the paper on the seconds pendulum before referred to, was firmly screwed to pickets driven into the ground at about eight feet and a half in front of the clock; and the Ys which supported the pendulum being lowered till the knife edge rested on the agate planes, the diaphragm of the telescope was

adjusted so as for its edges to coincide exactly with those of the extremity of the pendulum. The next step was to bring in a right line, the telescope, the extremity of the pendulum, and a white circle of the same diameter pasted on a black ground on the centre of the pendulum of the clock. For this purpose both pendulums being at rest, the telescope was slid laterally on its support* until a small particle of the disk was seen, and a mark was made on the support of the telescope with a pencil. The telescope was now slid in the opposite direction till an equal portion of the disk became visible, when another mark was made, and the telescope being placed so as to bisect these two marks, the centre of the object glass would evidently be in the prolongation of a line joining the white disk and the extremity of the pendulum.

The diaphragm was next brought by the circular horizontal movement of the telescope to correspond with the edges of the pendulum, and the divided arc for indicating the extent of the vibrations was placed so that its zero coincided with the extremity of the pendulum.

The same thermometer which was used in my former experiments and for the loan of which I was indebted to the kindness of Dr. WOLLASTON, was suspended on the clock case near the middle of the pendulum, and every thing being thus arranged, the pendulum of the clock was put in motion, and the knife edge elevated by means of the Ys above the agate planes, to prevent any injury when not in use.

A firm support for the transit instrument became the next object of attention, and for this purpose I tried a box nearly

* The wooden support was placed so as for the telescope to be within the limits of the sliding adjustment.

filled with sand, upon which a flat stone was laid. But as this did not prove so steady as I expected, a larger stone was afterwards procured and laid upon the box, and upon this the transit was placed.

The bell tent before mentioned was suspended over the transit from three spars lashed together at the top.

The *interval* of time between the transits of the same star being all that is required for the present purpose, it is not necessary that the transit instrument should be accurately in the meridian; it is sufficient that it should always describe the same vertical circle; it was however brought very near the meridian, at all the stations, by the following method:

The error of the chronometer was determined by altitudes of the sun, and the times were computed when the first and last limb would be on the meridian.

The axis of the transit was carefully levelled, and a little before the time of the sun's first limb coming to the meridian, the middle wire of the transit was brought in contact with it, and kept so by the horizontal adjustment till the calculated time of its arrival on the meridian. The position of the instrument was afterwards farther corrected if necessary by the transit of the second limb. At other of the stations, when the weather permitted, the instrument was brought extremely near the meridian by the transit of the pole star, the telescope being sufficiently powerful to command this star with ease, at any time of the day.

A mark (generally a flat board sharpened at one end to penetrate the ground) was sent to as great a distance as convenient, and so placed by signal, that it was bisected by the middle wire of the transit; and to this the instrument was

carefully adjusted previously to every observation. The preceding detail may serve, with very little difference, for each of the stations, and I have been thus minute in my description of the various adjustments necessary, in order that no difficulty may be experienced by any who may use the pendulum after me.

In observing the time of the transits, the chronometer was used, and was found to be particularly convenient from its beating half seconds. As soon as possible after the passage of the star, the chronometer was carefully compared with the clock, and the difference being applied to the time of the transit shown by the chronometer, and also the computed gain or loss of the clock during the interval between the observation and the comparison; the time shown by the clock at the instant of the transit was obtained.

These comparisons, as well as the whole of the data necessary for the examination of the results given in this paper, will be found in the Appendix.

The climate of Unst, at the season when I visited it, is such as to render the opportunities for celestial observations extremely rare. I had been informed, that the months of July and August were the most favourable, but on the contrary, I learnt on my arrival that they were considered the least so of any of the year, the atmosphere being generally clearest in May and September. Dense fogs and light rains succeeded each other, rarely permitting a sight of the sun; and it was not until the 22d of July, that I was able first to observe the transits of a few stars.

The following table contains the observations for the rate of the clock at Unst, derived from the table of transits given in the Appendix.

Transits observed at UNST.						
Stars.	July 22.	July 24.	July 25.	July 26.	July 27.	July 28.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
*The Sun	. . .	0.13.59,32	. . .	0.15.41,63	. . .	0.17.25,41
Arcturus	6.14.18,14	. . .	. . .	. . .	. . .	5.55.45,27
α Ophiuchi	. . .	. . .	9.23.43,56	. . .	. . .	9.14.30,51
ν Ophiuchi	9.55.36,41	. . .	9.46.18,11	. . .	. . .	9.37. 4,48
η Serpentis	10.18.25,08	. . .	10. 9. 6,1	. . .	. . .	9.59.52,73
α Lyræ	10.37.5	. . .	10.27.44,82	. . .	. . .	10.18.32,11
α Orionis	21.50.15,3	. . .	. . .	. . .	21.34.48,69	. . .

From the above data the following rates of the clock were obtained, by dividing the difference between the times of the transits of each star by the interval in days, and subtracting this from $3^m.55^s,91$, the acceleration of the fixed stars in 24 hours. To this, which is the rate of the clock in a sidereal day, the gain of the clock ($0^s,14$) in four minutes was added, to obtain the rate for a mean solar day.

Rate of the clock at UNST. (*Gaining.*)							
Stars.	From 22 to 28.	From 22 to 27.	From 22 to 25.	From 25 to 28.	From 24 to 28.	From 24 to 26.	From 26 to 28.
The Sun	. .	. .	. .	. .	51,10	50,10	52,09
Arcturus	50,57	. .	. .	. .	. .	. .	. .
α Ophiuchi	. .	. .	. .	51,70	. .	. .	. .
ν Ophiuchi	50,73	. .	49,95	51,41	. .	. .	. .
η Serpentis	50,66	. .	49,72	51,59	. .	. .	. .
α Lyræ	50,57	. .	49,32	51,81	. .	. .	. .
α Orionis	. .	50,73	. .	. .	. .	. .	. .
Mean by the Stars	50,63	50,73	49,66	51,63	. .	. .	. .
Mean by the Sun.	. .	. .	. .	. .	51,10	50,10	52,09

* To the observations of the sun the equation of time must always be applied, in order to obtain the rate of the clock.

On the 23d July I began to observe coincidences, in the manner described in my Paper on the length of the seconds pendulum. Two series, each of ten intervals were taken each day; these are given at large in the Appendix, the results were as follow:

Vibrations of the pendulum at Unst.
The clock making 86450,63 vibrations in a mean solar day.

Date.		Barometer.	Thermom.	Vibrations in 24 hours.	Correction for Temp.	Vibrations in 24 hours, at 62 degres.
July 23	P. M.	30,00	58°,4	86093,78	1,52	86092,26
	P. M.	30,30	59,3	86093,14	1,14	86092,00
	A. M.	29,90	57,3	86093,33	1,99	86091,34
24	P. M.	29,82	59,7	86092,45	0,97	86091,48
	A. M.	29,84	57,7	86093,12	1,82	86091,30
25	P. M.	29,72	59,0	86092,24	1,27	86090,97
	A. M.	29,95	57,8	86092,37	1,78	86090,59
26	The scapement was oiled without stopping the clock.					
27	A. M.	29,95	56,8	86091,69	2,20	86089,49
	P. M.	30,00	57,2	86091,62	2,03	86089,59
28	A. M.	30,15	54,3	86092,51	3,26	86089,25
	P. M.	30,20	58,0	86091,57	1,69	86089,88
Mean		29,98	57,8			86090,74

The numbers in the above Table are deduced from the rate of the clock (gaining $50^s,63$) between the 22d and 28th of July. For any other interval and rate, the mean of the vibrations during such interval is taken, and the difference between the corresponding rate and $50^s,63$ is added to, or subtracted from such mean number of vibrations accordingly as the rate of the clock has increased or diminished. The same method is pursued in all the subsequent experiments. In this manner the results contained in the next following table under the head of " computed vibrations in a mean solar day" were obtained.

The invariable pendulum furnishes a means of severely checking the rate of the clock; for should any alteration occur, it immediately indicates it. Thus on referring to the preceding table of "vibrations of the pendulum at 62°," it appears that from the 23d to the 28th of July, a gradual increase in the rate of the clock had taken place, amounting in the whole to a quantity equal to 2,5 vibrations of the pendulum, or 0,5 of a vibration in every 24 hours.

The rate of the clock, is that due to the *middle time* of the interval between the transits from which it is deduced. The number of vibrations of the pendulum is obtained for the *mean* of the times at which the coincidences were observed. If this mean should not coincide with the time for which the rate of the clock is obtained, and the rate of the clock should be variable, the number of vibrations of the pendulum computed on such given rate must evidently be erroneous. If the mean of the interval of the transits should be *before* the mean of the times of the coincidences, the number of vibrations will, in the present case of an accelerating rate, be in *defect*. If *after* the mean of the coincidences, they will be in *excess;* and the proportionate change of rate must be added or subtracted accordingly. On this principle the corrections were calculated and the results obtained, which are contained in the following table.

By the Stars. Unst.							
From	To	Computed Vibrations in a mean solar day.	Mean of Transits B or A coincidences.	Correction.	Corrected Vibrations in a mean solar day.	No. of Stars observed.	Inter. of Transit.
July.	July.		h. m.				
23 P. M.	28 P. M.	86090,71	B. 1. 27	+,03	86090,74	4	6
23 P. M.	28 A M.	86090,93	A. 1. 58	—,04	86090,89	1	5
23 P. M.	25 P. M.	86090,59	B. 2. 37	+,05	86090,64	3	3
26 A. M.	28 P. M.	86090,76	B. 5. 52	+,12	86090,88	4	3
By the Sun.							
24 P. M.	28 A. M.	86090,85	A. 1. 20	—,03	86090,82	2	4
24 P. M.	26 A. M.	86090,55	A. 0. 58	—,02	86090,53	2	2
26 P. M.	28 A. M.	86090,90	B. 6. 11	+,12	86091,02	2	2

We have now to consider what authority attaches to each result, so that we may employ all the observations in obtaining a mean, and yet give to each set that degree of weight only to which it is entitled.

The accuracy of any one result will evidently in the first place depend on the number of stars observed from which the rate of the clock is deduced; and on this head as may be seen by examining the table of transits, there is little probability of serious error.

But the position of the transit intrument with respect to the meridian mark, requires the most minute care, and I soon discovered that to this, and to the accurate levelling of the axis, it was necessary to pay unceasing attention, as a deviation equal to the diameter of the silkworm's thread in the focus of the eye glass, would occasion an error in the time of the transit of a star amounting to about three tenths of a second.

The effect of this error on the daily rate of the clock, is lessened in proportion to the number of days comprised between the two transits; for if the rate of the clock be deduced from transits observed on two successive days, the whole amount of the error arising from any deviation of the instrument from the meridian mark, will be included in the rate; but for any longer interval, it is divided by the number of days constituting such interval.

In order therefore to obtain a true mean, it appears that each result should be multiplied by the product of the number of the stars into the interval between the observations, and the sum of such final products be divided by the sum of the factors.

Observations of the sun are perhaps less entitled to credit than those of the stars, as in consequence of an apparent wavering of the meridian mark, some degree of uncertainty frequently exists in adjusting the transit instrument; setting this aside, a transit of both limbs of the sun may be considered equal to the transits of two stars.

Proceeding in the computation in the manner just described, we obtain 86090,77 vibrations of the pendulum in 24 hours, by the observations of the stars, and 86090,79 by those of the sun. But from what has been said, these results are entitled to credit in the ratio of the sums of their factors, that is, as 50 to 16; the final mean is therefore 86090,77 vibrations in a mean solar day.

The force of gravity decreasing as the square of the distance from the earth's centre increases, the next step is to find the correction on this supposition for the height of the station above the level of the sea. As the square of the

number of vibrations of the pendulum represents the force of gravity, we have this simple rule: convert the height of the station into the decimal of a mile, and divide it by the radius of the earth (3954,583) the quotient is the factor by which the number of vibrations in 24 hours being multiplied, the product will be the correction required.

But the quantity thus obtained is evidently erroneous, being founded on the supposition that the experiments are made on an elevation having no attractive matter surrounding it; and it is observed by Dr. YOUNG, in a letter which that eminent mathematician addressed to me, and which is published in the Phil. Trans. for 1819, entitled " Remarks on the probabilities " of error in physical observations, and on the density of the " earth, considered especially with regard to the reduction " of experiments on the pendulum;" that " if we were raised " on a sphere of earth a mile in diameter, its attraction would " be about $\frac{1}{8000}$ of that of the whole globe, and instead of a " reduction of $\frac{1}{2000}$ in the force of gravity, we should obtain " only $\frac{3}{8000}$, or $\frac{3}{4}$ as much. Nor is it at all probable, that " the attraction of any hill, a mile in height, would be so little " as this, even supposing its density to be only two thirds of " the mean density of the earth. That of a hemispherical " hill of the same height would be more than half as much " more (*than the sphere*) or in the proportion of 1,586 to 1. " And it may be easily shown, that the attraction of a large " tract of table land, considered as an extensive flat surface a " mile in thickness, would be three times as great as that of " a sphere a mile in diameter; or about twice as great as that " of such a sphere of the mean density of the earth: so that, " for a place so situated, the allowance for elevation would " be reduced to one half: and in almost any country that could

"be chosen for the experiment, it must remain less than three "fourths of the whole correction deduced immediately from "the duplicate proportion of the distances from the earth's "centre."

By this interesting, and I believe new view which Dr. YOUNG has taken of the subject, it appears that the correction for the elevation above the sea, will vary (according to the nature of the eminence and also its density) from one half to three fourths of the quantity before deduced from the squares of the distances from the earth's centre, and if the mean density of the earth be taken at 5,5, and that of the matter surrounding the station at 2,5, Dr. YOUNG is of opinion, that the quantity deduced from the duplicate ratio of the distances should be multiplied by $\frac{66}{100}$, to obtain the correction for a table land, and by $\frac{7}{10}$ for that of an eminence of moderate declivity.

By careful levelling, the height of the station at Unst above low water, was found to be 28 feet; whence we have 0,12 for the correction deduced from the squares of the distances from the earth's centre, and as the station at Unst was surrounded by hills composed of serpentine, I shall take $0{,}12 \times \frac{1}{2} = 0{,}06$ for the correction to be applied in order to obtain the number of vibrations which would be made at the level of the sea.

The last correction to be found, is for the buoyancy of the atmosphere. The manner in which this correction is derived, has been fully explained in the "Account of experiments for "determining the length of the seconds pendulum" before referred to. The specific gravities of the weight and bar of the pendulum, were carefully determined. That of the bar was found to be 8,628, and of the weight 8,603. The specific

gravity therefore of the whole pendulum may be taken at 8,610.

The mean height of the barometer during the experiments at Unst, was 29,98 inches, and that of the thermometer 57,°8. The weight of water is to that of air at 29,27 inches of the barometer, and 53° of the thermometer, as 836 to 1, and the expansion of air for each degree of the thermometer is $\frac{1}{480}$ of its bulk. From these data we find that the specific gravity of the pendulum was to that of air, at the time of the experiments, as 7099 to 1. The square of the number of vibrations must therefore be increased $\frac{1}{7099}$ part, or 6,07 be added to the number of vibrations in 24 hours, to obtain the number of vibrations which would be made during the same period in vacuo.

These corrections being added to the mean number of vibrations before given, we have 86096,90 for the number of vibrations made by the pendulum in a mean solar day, in vacuo at the level of the sea.

The very unfavourable weather which I experienced at Unst, prevented my obtaining so many observations for the rate of the clock, as I could have wished; but though the greatest difference between the seven resulting numbers of vibrations amounts to so much as 0,49, I think it probable, after a careful examination, that the final result must be within one tenth of a vibration of the truth.

On the 23d July, I was so fortunate as to obtain one series of meridional observations of the sun, with the repeating circle, for the latitude of the station, which will be given hereafter, and on the 29th I embarked on board the Cherokee, and took leave of my kind host Mr. Edmondstone, to whose most friendly hospitality the eloquent pen of M. Biot has

done but justice, and has left me nothing to add, but that I experienced from him every attention that could contribute to my personal comfort, and every anxious exertion that could tend to forward the enquiry in which I was engaged.

Operations at Portsoy.

On the first of August I arrived at Portsoy, near to which is Cowhythe, the next station of the trigonometrical survey, which I proposed to connect with my observations, and after much search for a place suited to my experiments, was kindly favoured by the Rev. Mr. Grant, with the use of his school-house, which was perfectly adapted to the purpose, the walls being thick, and firmly built of serpentine. I was also so fortunate as to obtain accommodations for myself, at a house belonging to a gentleman of the name of Watson, immediately adjoining the school-house, and whose garden afforded an excellent situation for the transit instrument.

On the 5th August I commenced the observations detailed in the Appendix, from which is extracted the following table for obtaining the rate of the clock:

Transits observed at Portsoy. 1st Series.

Stars.	August 5.	August 6.	August 7.	August 8.	August 10.	August 11.	August 12.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
The Sun	. . .	0.14.41,62	0.15. 7,95	0.15.36,56	0.16.38,83	. . .	0.17.42,63
Arcturus	. . .	. . .	. . .	5.11.20,51	5. 4 46,51	. . .	4.58.16,63
α Ophiuchi	. . .	8.36.42,60	. . .	8.30. 1,45	8.23.28,67	8.20.13,59	8.16.58,52
ι Ophiuchi	9. 2.35,99	. . .	. . .	8.52.29,70	8.45.56,85	8.42.41,94	8.39 26,94
η Serpentis	9.25.25,99	. . .	. . .	9.15.19,73	9. 8.46,76	9. 5.32,03	9. 2.17,04
α Lyræ	9.44.16,20	. . .	. . .	9.34.10,19	9.27.37,34	9.24.22,52	9 21. 7,43
a	. . .	. . .	. . .	. . .	9.53.22,62	9.50. 7,82	9.46.52,91
b	10.16.29,86	. . .	. . .	. . .	9.59.51,24	9.56.36,52	9.53.21,61
μ Aquilæ	10.38.33,58	. . .	. . .	. . .	. . .	10.18.40,52	10.15.25,11
α Aquilæ	10.55.13,62	. . .	. . .	10.45. 8,14	10.38.35,49	10.35 20,47	10.32. 5,33

From the above data the following rates of the clock were obtained, in the manner which has been before fully particularized.

Rate of the clock at PORTSOY, 1st Series.—(*Gaining.*)

Stars.	From 5 to 8.	From 5 to 10.	From 5 to 11.	From 5 to 12.	From 6 to 7.	From 6 to 8.	From 6 to 10.	From 6 to 12.	From 7 to 8.	From 7 to 10.	From 7 to 12.	From 8 to 10.	From 8 to 11.	From 8 to 12.	From 10 to 11.	From 10 to 12.	From 11 to 12.
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
The Sun	—	—	—	—	32,73	34,22	36,63	38,10	35,71	37,93	39,18	39,03	—	40,04	—	41,05	—
Arcturus	—	—	—	—	—	—	—	—	—	—	—	*39,02	—	*40,05	—	41,09	—
α Opiuchi	—	—	—	—	—	35,44	—	—	—	—	—	39,63	40,07	40,29	40,95	40,96	40,96
ν Ophiuchi	33,90	36,18	37,00	37,57	—	—	—	—	—	—	—	39,59	40,10	40,33	41,12	41,08	41,03
η Serpentis	33,91	36,16	37,02	37,59	—	—	—	—	—	—	—	39,54	40,12	40,35	41,30	41,17	41,04
α Lyræ .	34,00	36,24	37,06	37,61	—	—	—	—	—	—	—	39,59	40,13	40,33	41,21	41,08	40,94
a	—	—	—	—	—	—	—	—	—	—	—	—	—	—	41,23	41,18	41,12
b	—	36,29	37,12	37,69	—	—	—	—	—	—	—	—	—	—	41,31	41,22	41,12
μ Aquilæ	—	—	37,17	37,66	—	—	—	—	—	—	—	—	—	—	—	—	40,62
α Aquilæ	34,17	36,38	37,15	37,68	—	—	—	—	—	—	—	39,69	40,13	40,15	41,01	40,95	40,89
Mean by the Stars	34,00	36,25	37,09	37,63	—	35,44	—	—	—	—	—	39,61	40,11	40,29	41,16	41,09	40,96
Mean by the Sun	—	—	—	—	32,73	34,22	36,63	38,10	35,71	37,93	39,18	39,03	—	40,04	—	41,05	—

* These are rejected.

From the detail of the coincidences observed at Portsoy given in the Appendix, and from the rate of the clock from the 5th to the 12th, is derived the following Table.

Vibrations of the Pendulum at PORTSOY. 1st. Series. The clock making 86437,63 vibrations in a mean solar day.						
Date.		Barometer.	Thermom.	Vibrations in 24 hours.	Correction for Temp.	Vibrations in 24 hours, at 62 degrees.
Aug. 6	A. M.	29,95	64°,8	86085,53	1,18	86086,71
	P. M	30,00	65,2	86084,19	1,35	86085,54
7	A. M	29,89	62,3	86083,09	0,13	86083,22
	P. M	29,88	62,6	86082,30	0,25	86082,55
8	A. M	30,05	58,8	86081,61	1,35	86080,26
	P. M,	30,09	60,5	86081,11	0,63	86080,48
9	A. M.	30,04	60,4	86080,13	0,68	86079,45
	P. M.	30,04	60,5	86078,63	0,63	86078,00
10	A. M.	30,10	58,8	86078,39	1,35	86077,04
	P. M.	30,16	60,3	86077,56	0,72	86076,84
11	A. M.	30,28	56,6	86078,44	2,28	86076,16
	P. M.	30,27	60,0	86077,34	0,85	86076,49
12	A. M.	30,26	59,2	86076,92	1,18	86075,74
	P. M.	30,27	61,3	86076,51	0,30	86076,21
Mean . .		30,09	60,8			86079,62

On examining the preceding Table, it appears that the rate of the clock had pretty regularly increased to the surprising amount of 10^s,51 in the space of 7 days; which is an acceleration of 1^s,5 in every 24 hours; on this I shall have occasion to remark hereafter. From the foregoing data the following Table of the corrected vibrations of the pendulum in a mean solar day was computed, in the manner which has been before detailed.

By the Stars, Portsoy—1st Series.

From	To	Computed Vibrations in a mean solar day.	Mean of Transits B or A coincidences.	Correction.	Corrected Vibrations in a mean solar day.	No. of Stars observed.	Inter. of Transits.
August.	August.		h. m				
6 A. M.	8 P. M.	86079,50	B. 1.17	+0,08	86079,58	4	3
6 A. M.	10 P. M.	86079,63	B. 1.17	+0,08	86079,71	5	5
6 A. M.	11 P. M.	86079,69	B. 1.14	+0,08	86079,77	6	6
6 A. M.	12 P. M.	86079,62	B. 1.13	+0,08	86079,70	6	7
7 A. M.	8 P. M.	86079,44	B. 2.23	+0,16	86079,60	1	2
9 A. M.	10 P. M.	86079,81	B. 1.42	+0,10	86079,91	6	2
9 A. M.	11 P. M.	86079,81	B. 1.49	+0,11	86079,92	5	3
9 A. M.	12 P. M.	86079,65	B. 1.50	+0,11	86079,76	5	4
11 A. M.	11 P. M.	86079,86	B. 1.50	+0,11	86079,97	7	1
11 A. M.	12 P. M.	86079,61	B. 2.18	+0,14	86079,75	8	2
12 A. M.	12 P. M.	86079,30	B. 1.31	+0,09	86079,39	8	1
By the Sun. 1st Series.							
6 P. M.	7 A. M.	86079,48	A. 1.22	—0,08	86079,40	2	1
6 P. M.	8 A. M.	86079,48	A. 1.20	—0,08	86079,40	2	2
6 P. M.	10 A. M.	86079,82	A. 1.21	—0 08	86079,74	2	4
6 P. M.	12 A. M.	86079,78	A. 1.15	—0,08	86079,70	2	6
7 P. M.	8 A. M.	86079,48	A. 1.19	— 0,08	86079,40	2	1
7 P. M.	10 A. M.	86079,93	A. 1.19	—0,08	86079,85	2	3
7 P. M.	12 A. M.	86079,85	A. 1.14	—0,08	86079,77	2	5
8 P. M.	10 A. M.	86080.14	A. 1.20	—0,08	86080,06	2	2
8 P. M.	12 A. M.	86079,93	A. 1.13	—0,08	86079,85	2	4
10 P. M.	12 A. M.	86079,73	A. 1. 4	—0,07	86079,66	2	2

By using the number of stars observed and the intervals between the transits, to obtain a mean, in the manner described in the account of the experiments at Unst, we have 86079,74 vibrations by the observations of the stars, and 86079,73 by those of the sun; whence is derived 86079,74 for the final mean number of vibrations in 24 hours.

The height of the pendulum at Portsoy, above low water, was found by levelling to be 94 feet, the correction due to which is $0,39 \times \frac{6}{10}$* $= 0,23$.

* It may be necessary to remark, that no allowance has been attempted for any variation of density between the different stations, but solely for their form.

The mean height of the barometer during the experiments, was 30,09 inches, and the mean temperature 60°,8, from which data, and the specific gravity of the pendulum, we have 6,04 for the correction, on account of the buoyancy of the atmosphere.

Applying these corrections to the mean number of vibrations before found, we obtain 86086,01 for the final number of vibrations which would be made by the pendulum in a mean solar day, in vacuo, and at the level of the sea.

The rate of the clock having suffered a continual acceleration, as I have before stated, it became a subject of anxious importance to determine what effect this might possibly have on the result of the experiments; particularly as the same curious circumstance had taken place at Unst, at which station however the unfavourable weather prevented the commencement of my observations, until the acceleration had nearly attained its maximum. To satisfy myself on this point, I took down the clock on the 13th August, and having carefully cleaned it, began a new series of observations, which are given at large in the Appendix, and from which the following tables and results are derived:

Transits observed at PORTSOY. 2d Series.

Stars.	August 13.	August 14.	August 15.	August 16.	August 17.	August 18.	August 19.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
The Sun	0.11.47,72	—	0.12.49,27	0.13.19,72	0.13.49,88	—	0.14.49,28
Arcturus	4.48.35,44	—	4.42. 6,66	4.38.53,17	—	4.32.25,84	—
α Ophiuchi	8. 7.17,18	8. 4. 2,83	8. 0.48,78	7.57.34,88	7.54.21,23	—	—
ν Ophiuchi	—	8.26.31,46	8.23.16,94	—	8.16.49,55	8 13.36,30	—
η Serpentis	—	8.49.21,19	8.46. 7, 0	8.42.53,09	8.39.39,77	8.36.26,36	—
α Lyræ	—	9. 8.11,68	9. 4.57,59	9. 1.43,81	8.58.30,19	8.55.16,39	—
μ Aquilæ	—	10. 2.29,88	—	—	9.52.48,21	—	—
α Aquilæ	—	10.19. 9,84	—	—	10. 9.28,18	—	—

Rate of the clock at Portsoy. 2d Series. (*Gaining.*)

Stars.	From 13 to 14.	From 13 to 15.	From 13 to 16.	From 13 to 17.	From 13 to 18.	From 13 to 19.	From 14 to 15.	From 14 to 16.	From 14 to 17.	From 14 to 18.	From 15 to 16.	From 15 to 17.	From 15 to 18.	From 15 to 19.	From 16 to 17.	From 16 to 18.	From 16 to 19.	From 17 to 18.	From 17 to 19.
		s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
The Sun	—	41,62	41,80	41,91	—	42,18	—	—	—	—	42,15	42,20	—	42,45	42,26	—	42,55	—	42,70
Arcturus	—	41,63	41,93	—	42,10	—	—	—	—	—	42,53	—	42,41	—	—	42,36	—	—	—
α Ophiuchi	41,67	41,82	41,92	42,03	—	—	41,97	42,05	42,15	—	42,12	42,25	—	—	42,37	—	—	—	—
ν Ophiuchi	—	—	—	—	—	—	41,50	—	42,05	42,23	—	42,33	42,47	—	—	—	—	42,77	—
η Serpentis	—	—	—	—	—	—	41,83	41,97	42,21	42,31	42,11	42,41	42,47	—	42,70	42,66	—	42,61	—
α Lyræ	—	—	—	—	—	—	41,93	42,04	42,19	42,20	42,24	42,32	42,29	—	42,40	42,31	—	42,22	—
μ Aquilæ	—	—	—	—	—	—	—	—	42,13	—	—	—	—	—	—	—	—	—	—
α Aquilæ	—	—	—	—	—	—	—	—	42,13	—	—	—	—	—	—	—	—	—	—
Mean by the Stars	41,67	41,72	41,92	42,03	42,10	—	41,81	42,02	42,14	42,25	42,25	42,33	42,41	—	42,49	42,44	—	42,53	—
Mean by the Sun	—	41,62	41,80	41,91	—	42,18	—	—	—	—	42,15	42,20	—	42,45	42,26	—	42,55	—	42,70

Vibrations of the Pendulum at PORTSOY, 2d Series.
The clock making 86442,18 Vibrations in a mean solar day.

Date.		Barometer.	Thermom.	Vibrations in 24 hours.	Correction for Temp.	Vibrations in 24 hours at 62 degrees.
Aug. 13	A. M.	—	—	—	—	—
	P. M.	30,25	61,9	86081,04	0,04	86081,00
14	A. M.	30,25	60,3	86081,11	0,72	86080,39
	P. M.	30,27	62,4	86080,19	0,17	86080,36
15	A. M.	30,25	60,1	86080,85	0,80	86080,05
	P. M.	30,25	61,6	86080,13	0,17	86079,96
16	A. M.	30,18	58,4	86081,19	1,52	86079,67
	P. M.	30,17	60,9	86080,26	0,47	86079,79
17	A. M.	30,15	59,8	86080,60	0,93	86079,67
	P. M.	30,16	61,2	86080,11	0,34	86079,77
18	A. M.	30,14	58,4	86080,79	1,52	86079,27
	P. M.	30,14	60,2	86080,18	0,76	86079,42
19	A. M.	30,10	57,4	86080.85	1,95	86078,90
	P. M.	—	—	—	—	—
Mean		30,19	60,2			86079,85

It appears from the above Table, as well as by the comparisons of the clock with the chronometer, that the rate of the clock had been sufficiently uniform to render any correction on this head unnecessary; in the following Table therefore we have the number of vibrations made by the pendulum in a mean solar day.

By the Stars. 2d Series. Portsoy.				
From	To	Correct Vibrations in a mean solar day.	No. of stars observed.	Inter. of Transits.
14 A. M.	14 P. M.	86079,86	1	1
14 A. M.	15 P. M.	86079,73	2	2
14 A. M.	16 P. M.	86079,78	2	3
14 A. M.	17 P. M.	86079,81	1	4
14 A. M.	18 P. M.	86079,76	1	5
15 A. M.	15 P. M.	86079,63	4	1
15 A. M.	16 P. M.	86079,71	3	2
15 A. M.	17 P. M.	86079,78	6	3
15 A. M.	18 P. M.	86079,77	3	4
16 A. M.	16 P. M.	86079,80	4	1
16 A. M.	17 P. M.	86079,87	4	2
16 A. M.	18 P. M.	86079,83	4	3
17 A. M.	17 P. M.	86080,03	3	1
17 A. M.	18 P. M.	86079,79	3	2
18 A. M.	18 P M.	86079,69	3	1
By the Sun.		2d. Series.		
13 P. M.	15 A. M.	86079,89	2	2
13 P. M.	16 A. M.	86079,86	2	3
13 P. M.	17 A. M.	86079,84	2	4
13 P. M.	19 A. M.	86079,85	2	6
15 P. M.	16 A. M.	86079,78	2	1
15 P. M.	17 A. M.	86079,79	2	2
15 P. M.	19 A. M.	86079,83	2	4
16 P. M.	17 A. M.	86079,81	2	1
16 P. M.	19 A. M.	86079,84	2	3
17 P. M.	19 A. M.	86079,86	2	2

Employing the numbers of stars observed, and the intervals of the transits, as before, we obtain 86079,78 vibrations by the observations of the stars, and 86079,84 by those of the sun; and the sums of the factors being 96 and 56, we have 86079,80 for the final mean number of vibrations in 24 hours.

The mean height of the barometer was 30,19 inches, and that of the thermometer 60°,2, hence the correction for the buoyancy of the atmosphere is 6,07.

This correction, together with 0,23 (the correction for the height above the sea) being added to the mean number of vibrations, we have 86086,10 for the number of vibrations which would be made in a mean solar day, in vacuo, and at the level of the sea.

The difference between this result and that of the first series of experiments made under the most unfavourable circumstances of acceleration in the rate of the clock, being only 0,09, affords it is presumed a most satisfactory proof that no very important error is to be dreaded from this source in the observations at Unst.

Operations at Leith Fort.

Having completed the requisite observations for the latitude of my station, and for connecting it with Cowhythe, I quitted Portsoy for Edinburgh on the 20th August, leaving the instruments and party to come by sea.

Leith Fort was my next station, and here, as I could procure no lodgings in the neighbourhood, an officer of the Royal Artillery most kindly relinquished to me his quarters in the barracks. The Cherokee arrived on the 28th, and the instruments were landed the same evening.

On my first arrival at Edinburgh to embark for Unst, I had been introduced to Sir Howard Elphinstone, the chief engineer of the station, and received from him the assurance of every assistance in my experiments, which his department could furnish. Though to my regret he was now absent on duty, I was promptly supplied with such materials and artificers as were necessary, and on the 29th August my apparatus was firmly put up in one of the public store rooms of the Fort, which was excellently adapted to the purpose, and the

transit instrument placed on a massy stone foundation, erected for it on the ramparts.

On the 31st of August I commenced my observations, the results of which are given in the following Tables, and on the evening of the 7th of September, the transits of the same stars were again observed, but unfortunately the lamp which was attached to the meridian mark, for adjusting the transit instrument by night, not having been properly placed, these observations were of necessity rejected.

Transits observed at LEITH FORT. 1st Series.

Stars.	August 31.	September 2.	September 4.	September 5.	September 6.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
The Sun .	—	0. 9.18,05	—	0. 9.41,66	0. 9.51,50
α Capricorni	9 49.41,04	9.42.40,21	9.35.42,16	—	—
ε Aquarii .	—	10. 1.56,92	9.54.59,09	—	—
α Equulei .	10.37.46,18	10.30.45,31	10.23.47,39	—	—
β Aquarii .	10.52.59,93	10.45.59,62	10.39. 1,37	—	—
ε Pegasi .	11. 6.12,53	—	10.52.13,94	—	—
ο Aquarii .	11.24.50,38	11.17.49,91	11.10.51,95	—	—
γ Aquarii .	11.43. 8,89	—	11.29.10,60	—	—
κ Aquarii .	11.59.11,46	—	11.45.13,07	—	—
η Aquarii .	—	11.55.13,67	—	—	—
ξ Pegasi .	—	12. 1.24,05	11.54.26,26	—	—
				—	—

From these transits the following table was computed.

Rate of the clock at LEITH FORT. 1st Series. (*Gaining*.)

Stars.	From August 31, to Sept. 2.	From August 31, to Sept. 4.	From Sept. 2, to Sept. 4.	From Sept. 2, to 5.	From Sept. 2, to 6.	From Sept. 5, to 6
	s.	s.	s.	s.	s.	s.
The Sun .	—	—	—	27,04	27,69	29,64
α Capricorni	25,56	26,26	26,95	—	—	—
ε Aquarii .	—	—	27,07	—	—	—
α Equulei .	25,55	26,28	27,02	—	—	—
β Aquarii .	25,83	26,34	26,85	—	—	—
ε Pegasi .	—	26,33	—	—	—	—
ο Aquarii .	25,75	26,37	27,00	—	—	—
γ Aquarii .	—	26,41	—	—	—	—
κ Aquarii .	—	26,38	—	—	—	—
η Aquarii .	—	—	—	—	—	—
ξ Pegasi .	—	—	27,09	—	—	—
Mean by the Stars	25,67	26,34	27,00	—	—	—
Mean by the Sun	—	—	—	27,04	27,69	29,64

The steeple of Leith church, being very conveniently situated for the purpose, I was anxious to ascertain with what degree of precision the rate of the clock might be obtained, by observing the disappearance of stars behind the steeple, a method which I understand was employed by M. BIOT, in his late laborious experiments on the length of the pendulum, and which seems capable of great accuracy. For this purpose I used a powerful achromatic telescope, with which I was favoured by Mr. JARDINE from the observatory. The telescope was placed so as to rest against the door way of the room which contained the clock, and was directed towards the side of the steeple. On the evening of the 30th August, I obtained observations of the time of the disappearance of several stars, and on the 6th of September, two of these stars were again observed, but the rest were not visible. By these stars,

the rate of the clock appeared to be 26^s,85; which rate as it was deduced from the longest interval, has been used in computing the following Table.

Vibrations of the Pendulum at LEITH FORT. 1st. Series.
The clock making 86426,85 vibrations in a mean solar day.

Date.		Barometer.	Thermom.	Vibrations in 24 hours.	Correction for Temp.	Vibrations in 24 hours at 62 degrees.
Aug. 31	A. M.	29,95	56°,6	86078,34	2,28	86076,06
	P. M.	29,85	58,9	86077,50	1,30	86076,20
Sept. 1	A. M.	29,55	58,7	86076,08	1,40	86074,68
	P. M.	29,49	60,1	86075,72	0,80	86074,92
2	A. M.	29,58	58,4	86075,14	1,52	86073,62
	P. M.	29,68	59,9	86074,55	0,89	86073,66
3	A. M.	29,95	57,4	86075,13	1,95	86073,18
	P. M.	29,97	59,7	86074,13	0,97	86073,16
4	A. M.	29,78	59,5	86074,13	1,06	86073,07
	P. M.	29,76	61,9	86073,16	0,04	86073,12
5	A. M.	29,85	60,3	86072,43	0,72	86071,71
	P. M.	29,83	62,1	86071,57	+0,04	86071,61
6	A. M.	29,60	59,9	86070,85	0,89	86069,96
	P. M.	29,62	61,4	86070,33	0,25	86070,08
Mean		29,75	59,6			86073,21

By the above Table we may perceive, that though the clock had been cleaned so recently, its rate had notwithstanding encreased in seven days, about six seconds, or 0,85 in every 24 hours. On account of this acceleration it becomes necessary to apply a correction, in the manner which has been before explained, in order to obtain the true number of vibrations made by the pendulum in a mean solar day. The results are contained in the following Table.

By the Stars. 1st. Series. LEITH FORT.							
From	To	Computed Vibrations in a mean solar day.	Mean of Transits B. or A. coin.	Correction.	Corrected vibrations in a mean solar day.	No. of stars observed.	Inter. of Transits.
			h. m.				
1 A. M.	2 P. M.	86073,04	B. 1.33	+,05	86073,09	4	2
1 A. M.	4 P. M.	86073,16	B. 0.28	+,02	86073,18	7	4
3 A. M.	4 P. M.	86073,28	B. 0.27	+,02	86073,30	6	2
By disappearance of stars behind Leith steeple.		86073,21	A. 0.33	—,02	86073,19	2	7
By the Sun. 1st. Series.							
2 P. M.	5 A. M.	86073,17	A. 0.57	—0,3	86073,14	2	3
2 P. M.	6 A. M.	86073,28	A. 1. 9	—0,3	86073,24	2	4
5 P. M.	6 A. M.	86073,57	A. 0.51	—0,3	86073,54	2	1

Using the number of stars observed and the intervals of the transits, as before, to obtain a mean, we have 86073,19 vibrations by the stars, and 86073,23 by the sun, and the sums of the factors, being 62 and 16, we obtain 86073,20 for the final mean number of vibrations in 24 hours.

The mean height of the barometer was 29,75 inches, and the mean temperature 59°,6. The correction for the buoyancy of the atmosphere is therefore 5,99.

The height of the pendulum above low water, was found by levelling to be 68 feet, whence we have $0,28 \times \frac{66}{100} = 0,18$ for the correction due to this elevation.

These corrections being applied, we obtain 86079,37 for the number of vibrations made by the pendulum in a mean solar day in vacuo, and at the level of the sea.

The clock was now taken down to be cleaned, as I had resolved to go through a new series of observations. On examining the oil, it was found to all appearance as pure as

when first applied, and I can in no way account for the acceleration in the rate of the clock, but by supposing, that whilst it was at rest, the external surface of the oil had become thickened by some action of the sea air upon it. This would of course occasion the rate to be less, on the clock being first put up, and a gradual acceleration would afterwards take place as the thick coat of the oil became blended with the more fluid particles beneath. These remarks may perhaps warrant the important inference, that no reliance whatever can be placed on results obtained by means of a pendulum attached to a clock, and that until oil can be banished from chronometers, and the maintaining power be such as to be equal under all circumstances, we may spare ourselves the trouble of attending to other sources of error.

The clock being cleaned, the observations were made and the results deduced which are contained in the following Tables.

Transits observed at Leith Fort. 2d Series.

Stars.	September 8.	September 10.	September 12.	September 14.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.
α Equulei	10. 2.39,48	9.55.54.46	9.49.11,23	9.42.28,05
β Aquarii	10.17.53,83	10.11. 8,88	10. 4.25,60	—
ε Pegasi	10.31. 6,30	10.24.21,36	—	10.10.54,92
ο Aquarii	10.49.44,22	—	10.36.16,20	10.29.32,78
Pegasi	11.14.25,06	11. 7.39,80	11. 0.56,53	10.54.13,42
κ Aquarii	11.24. 5,68	11.17.20,66	11.10.37,38	11. 3.54,32
ζ Pegasi	11.28. 6,69	11.21.21,70	11.14.38,28	11. 7.55,24
ξ Pegasi	11.33.18,73	11.26.33,72	11.19.50,34	11.13. 7,40
α Pegasi	11.51.21,57	11.44.36,50	11.37.53,33	11.31.10,33

Rate of the clock at LEITH FORT. 2d. Series. *(Gaining.)*						
Stars.	From September 8 to 10.	From 8 to 12.	From 8 to 14.	From 10 to 12.	From 10 to 14.	From 12 to 14.
	s.	s.	s.	s.	s.	s.
α Equulei	33,49	33,94	34,10	34,39	34,40	34,41
β Aquarii	33,53	33,94	—	34,36	—	—
ε Pegasi	33,53	—	34,10	—	34,39	—
ο Aquarii	—	33,99	34,09	—	—	34,29
Pegasi	33,37	33,87	34,06	34,37	34,41	34,45
κ Aquarii	33,49	33,93	34,11	34,36	34,41	34,47
ζ Pegasi	33,51	33,90	34,09	34,29	34,39	34,48
ξ Pegasi	33,50	33,90	34,11	34,31	34,42	34,53
α Pegasi	33,47	33,94	34,13	34,42	34,46	34,50
Mean -	33,49	33,93	34,10	34,36	34,41	34,45

Vibrations of the Pendulum at LEITH FORT. 2d Series.
The clock making 86434,10 vibrations in a mean solar day.

Date.		Barometer.	Thermom.	Vibrations in 24 hours.	Correction for Temp.	Vibrations in 24 hours at 62 degrees.
Sept. 9	A. M.	29,90	54°,2	86077,10	3,30	86073,80
	P. M.	29,95	55,6	86076,63	2,71	86073,92
10	A. M.	29,94	52,4	86077,45	4,06	86073,39
	P. M.	29,91	54,2	86076,98	3,30	86073,68
12	A. M.	29,92	51,5	86077,16	4,44	86072,72
	P. M.	29,95	53,3	86076,71	3,68	86073,03
12	A. M.	30,14	53,1	86076,64	3,77	86072,87
	P. M.	30,14	54,2	86076,22	3,30	86072,92
13	A. M.	30,28	54,0	86076,05	3,38	86072,67
	P. M.	30,24	55,9	86075,40	2,58	86072,82
14	A. M.	29,89	56,4	86075,35	2,37	86072,98
	P. M.	29,85	57,1	86074,86	2,07	86072,79
Mean		30,01	54,3			86073,13

We may perceive from the above Table, that the rate of the clock had encreased about a second in six days; the error however affecting the final number of vibrations of the pendulum, in consequence of this, is too small to need correction.

By the Stars. LEITH FORT. 2d Series.				
From	To	Correct Vibrations in a Mean solar day.	No. of stars observed.	Interv. of Transits.
9 A. M.	10 P. M.	86073,09	8	2
9 A. M.	12 P. M.	86073,12	8	4
9 A. M.	14 P. M.	86073,13	8	6
11 A. M.	12 P. M.	86073,14	7	2
11 A. M.	14 P. M.	86073,16	7	4
13 A. M.	14 P. M.	86073,17	7	2

Using the number of stars observed, and the intervals between the transits as before, we have 86073,13 for the number of vibrations in 24 hours.

The barometer being at 30,01 inches, and the thermometer at 54°,3 the correction for the buoyancy of the atmosphere is 6,11.

This correction, together with 0,18, the correction for the height above the sea, being applied, we obtain 86079,42 for the number of vibrations made by the pendulum in vacuo, as deduced from the second series, from which the result of the first series differs 0,05 of a vibration. The mean of both is to be preferred.

Operations at Clifton.

On the 17th of September I left Edinburgh, and proceeded to Clifton in Yorkshire; at which place my instruments and party arrived on the 28th. Here I was so fortunate as to meet with a vacant house in the village, perfectly suited to my purpose, belonging to Mr. MILWARD, who is also proprietor of the field in which is the station of the Trigonometrical Survey. Previous to the commencement of my experiments, the clock was carefully cleaned. The observations were then made, and

the results deduced which are contained in the following Tables.

Transits observed at CLIFTON.

Stars.	October 2.	October 3.	October 5.	October 6.	October 8.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
The Sun	—	11.49. 6, 5	11.48. 8,64	11.47.40,36	11.46.45,38
σ Aquilæ	6.46.47,45	6.42.40,48	6.34.27,35	6.30.20,82	6.22. 8,92
α Aquilæ	6.58.27,38	6.54.20,37	6.46. 7,22	6.42. 0,57	—
θ Aquilæ	7.18.23,75	7.14.16,85	7. 6. 3,75	7. 1.57,15	6.53.44,63
ε Aquarii	—	7.50. 4,50	7.41.51,28	7.37.44,75	7.29.32,8
η Capricorni	—	8. 6.13,77	—	—	—
α Equulei	8.23. 2,35	8.18.55,28	—	8. 6.35,35	7.58.23,28
ε Capricorni	8.43. 5,98	8.38.58,87	—	8.26.39,37	8.18.27,2
α Aquarii	9.12.35,95	9. 8.29,15	9. 0.15,68	8.56. 9,23	8.47.57,07
γ Aquarii	9.28.22,38	9.24.15,47	9.16. 2,27	9.11.55,72	—
η Aquarii	—	9.37.58, 1	9.29.44,92	9.25.38,43	9.17.26,37

Rate of the clock at CLIFTON. (*Losing.*)

Stars.	From Oct. 2, to 3.	From 2 to 5.	From 2 to 6.	From 2 to 8.	From 3 to 5.	From 3 to 6.	From 3 to 8.	From 5 to 6	From 5 to 8.	From 6 to 8.
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
The Sun	—	—	—	—	10,78	10,75	10,62	10,68	10,52	10,44
σ Aquilæ	11,09	10,82	10,78	10,54	10,68	10,67	10,43	10,65	10,26	10,07
α Aquilæ	11,13	10,84	10,82	—	10,69	10,72	—	10,77	—	—
θ Aquilæ	11,03	10,79	10,77	10,64	10,67	10,69	10,56	10,72	10,49	10,38
ε Aquarii	—	—	—	—	10,73	10,70	10,46	10,65	10,28	10,09
η Capricorni	—	—	—	—	—	—	—	—	—	—
α Equulei	11,19	—	10,87	10,63	—	10,76	10,52	—	—	10,15
ε Capricorni	11,23	—	10,77	10,58	—	10,62	10,45	—	—	10,20
α Aquarii	10,92	10,88	10,80	10,60	10,85	10,76	10,54	10,57	10,32	10,20
γ Aquarii	11,03	10,82	10,78	—	10,72	10,70	—	10,67	—	—
η Aquarii	—	—	—	—	10,71	10,68	10,47	10,61	10,30	10,15
Mean by the Stars	11,09	10,83	10,80	10,60	10,72	10,70	10,49	10,66	10,33	10,18
Mean by the Sun	—	—	—	—	10,78	10,75	10,62	10,68	10,52	10,44

Vibrations of the Pendulum at CLIFTON. The clock making 86389,40 vibrations in a mean solar day.						
Date.		Barometer.	Thermom.	Vibrations in 24 hours.	Correctiou for Temp.	Vibrations in 24 hours, at at 62 degrees.
Oct.			°			
3	A. M.	29,22	57,4	86064,52	1,95	86062,57
	P. M.	29,20	58,2	86063,92	1,61	86062,31
4	A. M.	29,18	57,2	86064,44	2,03	86062,41
	P. M.	29,13	57,2	86064,18	2,03	86062,15
5	A. M.	29,10	55,1	86065,26	2,92	86062,34
	P. M.	29,08	55,7	86064,93	2,67	86062,26
6	A. M.	29,01	53,4	86065,75	3,64	86062,11
	P. M.	29,10	54,5	86065,08	3,17	86061,91
7	A. M.	29,30	52,9	86065,47	3,85	86061,62
	P. M.	29,33	53,7	86065,25	3,51	86061,74
8	A. M.	29,52	52,2	86065,36	4,15	86061,21
	P. M.	29,57	52,9	86065,08	3,85	86061,23
	Mean	29,23	55,0	–		86061,99

From the preceding Tables, the following vibrations in a mean solar day were computed.

By the Stars. CLIFTON.				
From	To	Correct Vibrations in a mean solar day.	No. of Stars observed.	Interv. of Transits.
3 A. M.	3 P. M.	86061,95	7	1
3 A. M.	5 P. M.	86062,11	5	3
3 A. M.	6 P. M.	86062.06	7	4
3 A. M.	8 P. M.	86061,99	5	6
4 A. M.	5 P. M.	86062,17	7	2
4 A. M.	6 P. M.	86062,10	9	3
4 A. M.	8 P. M.	86062,01	7	5
6 A. M.	6 P. M.	86061,95	7	1
6 A. M.	8 P. M.	86061,91	5	3
7 A. M.	8 P. M.	86061,87	7	2
By the Sun.				
3 P. M.	5 A. M.	86062,12	2	2
3 P. M.	6 A. M.	86062,11	2	3
3 P. M.	8 A. M.	86061,99	2	5
5 P. M.	6 A. M.	86062,10	2	1
5 P. M.	8 A. M.	86061,89	2	3
6 P. M.	8 A. M.	86061,78	2	2

The number of stars observed, and the intervals between the transits being employed as before to obtain a mean, we have 86062,02 vibrations by the stars, and 86061,99 by the sun, whence we obtain 86062,01 for the final mean number of vibrations in 24 hours.

The height of the barometer being 29,23 inches, and the thermometer 55°,0 the resulting correction for the buoyancy of the atmosphere is 5,94.

The height of Clifton Beacon, above the level of the sea is stated in the " Account of the Trigonometrical Survey" to be 417 feet; and by levelling, the pendulum was found to be 78 feet below Clifton Beacon, the height of the pendulum therefore above the level of the sea was 339 feet, the correction for which is $1,40 \times \frac{68}{100} = 0,95$.

Applying these corrections, we obtain 86068,90 for the number of vibrations at Clifton, in a mean solar day, in vacuo and at the level of the sea.

Operations at Arbury Hill.

On the 13th of October I left Clifton, having previously made some important observations for the latitude, which will be detailed in the proper place, and proceeded to Arbury Hill, where my party and instruments arrived on the 15th. Here I procured accommodations at a house belonging to Mr. GOSSAGE, situated on the side of an eminence, to the south of Arbury Hill. The season was now so far advanced, and the weather in consequence so variable, that it was not until the 21st that I was able to commence my observations. These though few in number, were made with such minute precautions, and under such favourable circumstances, as to be perfectly satisfactory to me. The following Tables contain the results.

Transits observed at Arbury Hill.

Stars.	October 21.	October 25.	October 26.
	h. m. s.	h. m. s.	h. m. s.
The Sun	11.44.28,39	—	11 43.17,93
σ Aquilæ	5.31.39,53	5.15.30,75	5.11.29,10
α Aquilæ	5.43.19,17	5.27.10,42	5.23. 8,78
θ Aquilæ	6. 3.16,55	5.47. 7,78	5.43. 6,05

Rate of the clock at Arbury Hill. (*Losing.*)

Stars.	From 21 to 25.	From 21 to 26.	From 25 to 26.
	s.	s.	s.
The Sun .	—	6,23	—
σ Aquilæ .	6,30	6,20	5,76
α Aquilæ .	6,30	6,19	5,75
θ Aquilæ .	6,30	6,21	5,84
Mean by the Stars . .	6,30	6,20	5,78
Mean by the Sun . .	—	6,23	—

Vibrations of the Pendulum at Arbury Hill.
The clock making 86393,80 vibrations in a mean solar day.

Date.		Barometer.	Thermom.	Vibrations in 24 hours.	Correction for Temp.	Vibrations in 24 hours, at 62 degrees.
Oct.			°			
21	A. M.	—	—	—	—	—
	P. M.	29,65	56,7	86059,25	2,24	86057,01
22	A. M.	29,52	54,2	86060,66	3,30	86057,36
	P. M.	29,50	54,4	86060,52	3,22	86057,30
23	A. M.	29,50	52,8	86061,07	3,89	86057,18
	P. M.	29,52	53,2	86060,88	3,72	86057,16
24	A. M.	29,57	50,8	86061,40	4,74	86056,66
	P. M.	29,55	50,6	86061,28	4,82	86056,46
25	A. M.	29,56	50,9	86061,40	4,70	86056,70
	P. M.	29,54	52,3	86061,00	4,10	86056,90
26	A. M.	29,55	52,2	86060,63	4,15	86056,48
	P. M.	29,55	53,7	86060,12	3,51	86056,61
Mean		29,55	52,9			86056,88

From the preceding Tables were deduced the following vibrations in a mean solar day.

By the Stars. ARBURY HILL.				
From	To	Correct Vibrations in a mean solar day.	No. of Stars observed	Interv. of Transits.
22 A. M.	25 P. M.	86056,86	3	4
22 A. M.	26 P. M.	86056,88	3	5
26 A. M.	26 P. M.	86056,96	3	1
By the Sun.				
21 P. M.	26 A. M.	86056,89	2	5

From the number of stars observed, and the intervals of the transits, we derive 86056,88 for the mean by the stars, 86056,89 by the sun, and 86056,88 for the final mean number of vibrations in 24 hours.

The barometer being at 29,55 inches, and the thermometer at 52°,9 we have 6,04 for the correction on account of the buoyancy of the atmosphere.

The angle of elevation of the top of the tent on Arbury Hill, taken by the repeating circle from the station where the clock was placed, was found to be 1°.28′.21″,4; and as it will appear in the Appendix, that the distance from the station on Arbury Hill to the clock, was 3048 feet, we have 78 feet very nearly for the elevation of the top of the tent above the pendulum. The elevation of Arbury Hill above the sea, as determined by the Trigonometrical Survey, is 804 feet, from which deducting 67 feet, (the height of the tent being 11 feet,) we obtain 737 feet for the elevation of the pendulum above the

level of the sea, the correction for which is $3{,}04 \times \frac{7}{10} = 2{,}13$. These corrections being applied, we have 86065,05 for the number of vibrations which would be made by the pendulum in a mean solar day in vacuo and at the level of the sea.

On leaving Arbury Hill, I hastened to Dunnose in the Isle of Wight, anxious to complete my experiments before the winter; but on arriving there, I found the weather so bad, that after a short stay I was reluctantly obliged to postpone my observations at that station until the following spring.

Operations at London.

Before I left London in June, I took four series of vibrations of the pendulum at a high temperature, at Mr. Browne's house in Portland Place; chiefly with a view to afford me the means of checking my expansion of the pendulum by a comparison with other series of vibrations, which I purposed to observe at a low temperature on my return, and also to enable me to form some idea of the acceleration, when I should arrive at Unst. For the rate of the clock I am indebted to the observations of Mr. Browne. The results are contained in the following Table.

Vibrations of the Pendulum at London.—1st Series.

Date, 1818.	Barometer.	Thermom.	Vibrations in 24 hours.	Correction for Temp.	Correct Vibrations in a mean solar day at 62 degrees.
June		°			
13	29,90	71,6	86051,32	4,06	86055,38
14	30,00	70,1	86051,90	3,43	86055,33
15	30,05	69,9	86051,99	3,34	86055,33
16	29,95	70,5	86051,82	3,60	86055,42
Mean	29,98	70,5			86055,36

The barometer being at 29,98 inches, and the thermometer

at 70°,5 the correction for the buoyancy of the atmosphere is 5,91.

The height of the pendulum above the level of the sea was 83 feet, the correction for which is 0,34 $\times \frac{66}{100}$ = 0,22.

These corrections being applied, we have 86061,49 vibrations in a mean solar day, at the temperature of 62° in vacuo, and at the level of the sea.

Various causes prevented me from repeating my experiments in London, until the month of March, when the following results were obtained, the observations on which they are founded being detailed in the Appendix.

Vibrations of the Pendulum at London.—2nd Series.

Date. 1819.	Barometer.	Thermom.	Vibrations in 24 hours.	Correction for Temp.	Correct Vibrations in a mean solar day, in vacuo at 62°
March		°			
8	30,10	50,0	86060,12	5,08	86055,04
9	30,10	50,1	86060,21	5,03	86055,18
15	30,14	51,8	86059,41	4,32	86055,09
16	30,00	52,7	86058,98	3,93	86055,05
17	30,10	53,5	86058,92	3,60	86055,32
18	30,21	52,8	86058,93	3,89	86055,04
Mean	30,11	51,8			86055,12

The correction for the buoyancy of the atmosphere is 6,18, and that for the height above the level of the sea, 0,22. We have therefore 86061,52 for the number of vibrations at 62° in vacuo, and at the level of the sea.

So very near an agreement with my former observations, after an allowance for a difference of temperature amounting to 18°,7 I could scarcely have dared to hope for, and it afforded me a most satisfactory assurance, not only that the

knife edge of the pendulum had suffered no injury from use, but that my allowance for expansion was correct, a circumstance of the greatest importance to the truth of my results, and respecting which there might have been most reason to apprehend error.

Operations at the Isle of Wight.

On the 8th May 1819, I again left London for the Isle of Wight. Dunnose, the most southern station of the meridional arc of the Trigonometrical Survey, is marked by an iron gun, sunk in the ground on the summit of a hill near the village of Shanklin, a little to the north of a signal post.* The nearest house to this station is Shanklin Farm, in the occupation of Mr. Jolliffe, from whom and from the proprietor, the Rev. Mr. White, I most readily received permission to make use of a summer house, well suited to the purpose, for my experiments.

The observations made at this station are detailed in the Appendix. The weather was very favourable after the 12th; and though before that period I was not able to obtain the transit of more than one star and of the sun, these observations were satisfactory. The results are contained in the following Tables.

Transits observed at Shanklin Farm.

Stars.	May 10.	May 11.	May 12.	May 13.	May 14.	May 15.	May 16.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
The Sun	—	0.0.49,49	—	0.0.26,89	0.0.16,44	0. 0. 6,51	11.59.57,71
Regulus	6.52.37,32	—	—	6.40.21,23	—	6.32.10,35	6.28. 5,65
x.	—	—	9.11.21,26	—	—	—	8.55. 0,74
ε Virginis	—	—	9.38 24,16	—	—	—	9.22. 2,83
α Virginis	—	—	10. 0.49,30	—	—	—	9.44.28,08
τ Bootæ	—	—	10.23.46,29	—	—	—	10. 7.25,28
η Bootæ	—	—	10.31. 9,37	—	—	—	10.14.38,58
Arcturus	—	—	10.52.26,25	—	—	—	10.36. 5,44

* The height on which the station is situated, is properly called *Shanklin Down*; Dunnose is the next projecting point to the southward.

Rate of the clock at SHANKLIN FARM.—(*Losing.*)

Stars.	From 10 to 13.	From 10 to 15.	From 10 to 16.	From 11 to 13.	From 11 to 14.	From 11 to 15.	From 11 to 16.	From 12 to 16.	From 13 to 14.	From 13 to 15.	From 13 to 16.	From 14 to 15.	From 14 to 16.	From 15 to 16.
	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
The Sun .	—	—	—	9,35	9,38	9,42	9,34	—	9,45	9,49	9,33	9,53	9,26	9,00
Regulus .	9,48	9,51	9,40	—	—	—	—	—	—	9,56	9,31	—	—	8,82
x.	—	—	—	—	—	—	—	9,25	—	—	—	—	—	—
ε Virginis .	—	—	—	—	—	—	—	9,40	—	—	—	—	—	—
α Virginis .	—	—	—	—	—	—	—	9,42	—	—	—	—	—	—
τ Bootæ .	—	—	—	—	—	—	—	9,37	—	—	—	—	—	—
η Bootæ .	—	—	—	—	—	—	—	9,32	—	—	—	—	—	—
Arcturus .	—	—	—	—	—	—	—	9,32	—	—	—	—	—	—
Mean by Regulus	9,48	9,51	9,40	—	—	—	—	—	—	9,56	9,31	—	—	8,82
Mean by the other Stars	—	—	—	—	—	—	—	9,35	—	—	—	—	—	—
Mean by the Sun . .	—	—	—	9,35	9,38	9,42	9,34	—	9,45	9,49	9,33	9,53	9,26	9,00

Vibrations of the Pendulum at Shanklin Farm,

The clock making 86390,60 vibrations in a mean solar day.

Date.		Barometer.	Thermom.	Vibrations in 24 hours.	Correction for Temp.	Vibrations in 24 hours at 62 degrees.
May 11	A. M.	30,17	60,9 °	86052,14	0,47	86051,67
	P. M.	30,16	61,8	86051,73	0,08	86051,65
12	A. M.	30,10	61,0	86051,96	0,42	86051,54
	P. M.	30,09	61,3	86051,85	0,30	86051,55
13	A. M.	30,08	60,8	86051,73	0,51	86051,22
	P. M.	30,08	61,0	86051,64	0,42	86051,22
14	A. M.	30,14	60,5	86052,14	0,63	86051,51
	P. M.	30,10	60,8	86051,97	0,51	86051,46
15	A. M.	30,05	60,9	86051,44	0,47	86050,97
	P. M.	30,05	61,3	86051,28	0,30	86050,98
16	A. M.	30,03	60,1	86051,70	0,80	86050,90
	P. M.	30,03	60,7	86051,34	0,55	86050,79
Mean		30,09	60,9			86051,29

From the preceding tables were deduced the following vibrations in a mean solar day.

By Regulus. Shanklin Farm.

From	To	Correct vibrations in a mean solar day.	No. of stars observed.	Interv. of Trans.
11 A. M.	13 P. M.	86051,39	1	3
11 A. M.	15 P. M.	86051,27	1	5
11 A. M.	16 P. M.	86051,29	1	6
14 A. M.	15 P. M.	86051,17	1	2
14 A. M.	16 P. M.	86051,19	1	3
16 A. M.	16 P. M.	86051,42	1	1
By other Stars.				
13 A. M.	16 P. M.	86051,18	6	4

By the Sun.				
From	To	Correct vibrations in a mean solar day.	No. of stars observed.	Inter. of Transits.
11 P. M.	13 A. M.	86051,54	2	2
11 P. M.	14 A. M.	86051,47	2	3
11 P. M.	15 A. M.	86051,37	2	4
11 P. M.	16 A. M.	86051,36	2	5
13 P. M	14 A. M.	86051,31	2	1
13 P. M.	15 A. M.	86051,20	2	2
13 P. M.	16 A. M.	86051,24	2	3
14 P. M.	15 A. M.	86051,08	2	1
14 P. M.	16 A. M.	86051,22	2	2
15 P. M.	16 A. M.	86051,34	2	1

The number of stars observed and the intervals between the transits being employed as before to obtain a mean, we have 86051,28 vibrations by Regulus, 86051,18 by the other stars, and 86051,34 by the sun; and the sum of the respective factors being 20, 24, and 48, we obtain 86051,28 for the final mean number of vibrations in 24 hours.

The mean height of the barometer being 30,09 inches, and that of the thermometer 60°,9, the correction for the buoyancy of the atmosphere is 6,09.

It may be seen in the Appendix, that the height of Dunnose above the summer house, deduced from the distance and angle of elevation of the signal post, is 539 feet; and as Dunnose is stated, in the Trigonometrical Survey, to be 792 feet above the level of the sea, this would give 253 feet for the elevation of the pendulum above the sea. But by observations made with a barometer of Sir HARRY ENGLEFIELD's construction, on three several days, the greatest difference of the results being eight feet, the mean elevation of the summer house above high water mark appeared to be 221 feet; and if 10 feet be allowed for the fall of the tide, we have 231 feet, for the height of the pendulum above low water, differing

from the former result 22 feet. The height of Dunnose above the summer house, was also deduced barometrically, and appeared to be 513 feet, differing from the trigonometrical determination 26 feet in defect. If this difference be attributed to error in the barometer, as is most probably the fact, the proportional error in the elevation of the summer house, determined barometrically, will be 11 feet, and this being added to 231 feet, we have 242 feet for the height of the pendulum above the level of the sea, which is probably within eleven feet of the truth.

The correction due to an elevation of 242 feet, is $0,997 \times \frac{7}{10} = 0,70$; and this, together with the correction for the buoyancy of the atmosphere being added to the number of vibrations before found, we obtain 86058,07 for the number of vibrations which would be made by the pendulum in a mean solar day, in vacuo, and at the level of the sea.

Of the Latitudes and Longitudes of the different Stations.

The daily rate of Mr. BROWNE's chronometer before I left London, was — $0^s,2$ the chronometer being too slow for Greenwich time on the 15th June $1^m.15^s,75$; but this rate, as might have been expected, varied from the motion of the waggon or other causes, so that at Unst, its mean rate was — $1^s,32$, at Portsoy — $1^s,7$, and at Leith — $2^s,42$, which rates are deduced from the column headed "chronometer," in the table of transits given in the Appendix.

The meridian of my station at Leith Fort, passed within 40 feet of that of the observatory on the Calton Hill, the longitude of which Mr. JARDINE, who has the care of the observatory, informed me, is $12^m.46^s,7$ west of Greenwich, which may also be considered as the longitude of my station. At Leith Fort, on the 17th September, by two sets of altitudes of the sun, taken with the repeating circle and given in the Appendix, the chronometer was found to be $8^m.41^s,6$ too fast, and as it was slow at Greenwich on the 15th June $1^m.15,75$, it had lost between that period and the 17th September, $2^m.49^s,35$, which is at the rate of $1^s,8$ daily.

At Unst, by four series of altitudes of the sun, taken on the 22d July with the repeating circle, (which I conceive it is unnecessary to detail, as the results differed very little from each other) the chronometer appeared to be $50^s,2$ fast, to which $1^m.15^s,75$ being added, and also $1^m.6^s,6$ (the loss of the chronometer in 37 days) we obtain $3^m.12^s,55$ for the longitude of Unst in time, west of Greenwich.

Again. Taking Leith for the point of departure, we have the chronometer fast on the 17th September $8^m.41^s,6$, and at

Unst, on the 22d July, $50^s,2$. The mean of the rates of the chronometer at Unst, Portsoy, and Leith, gives $1^s,81$ for the mean daily rate, which being multiplied by 57, the number of days between the 22d of July and the 17th September, we have $1^m.43^s,17$ for the loss of the chronometer during that period. This being added to $8^m.41^s,6$, we obtain $10^m.24^s,77$ for the error of the chronometer on the 22d July, for the meridian of Leith, and subtracting $50^s,2$ (the error at Unst) the remainder $9^m.34^s,57$ will be the longitude of Unst, east of Leith. Now the longitude of Leith being $12^m.46^s,7$ west, the difference $3^m.12^s,13$ will be the longitude of Unst, west of Greenwich. This agreeing so nearly with the preceding result, may perhaps be considered as not very far from the truth.

At Portsoy on the 3d August, the chronometer was found to be $7^m.52^s,3$ too fast, by altitudes of the sun, which are detailed in the Appendix. The loss of the chronometer from the 15th June to the 3d August, at the daily rate of $1^s,8$ is $1^m.28^s,2$; which, together with $1^m.15^s,75$ (the error of the chronometer at Greenwich on the 15th June) being added to $7^m.52^s,3$, we obtain $10^m.36^s,25$ for the longitude of Portsoy, west of Greenwich.

In order to deduce the longitude of Portsoy from that of Unst, we have the chronometer fast at Unst on the 22d July $50^s,2$, and at Portsoy on the 3d August $7^m.52^s,3$. The mean of the daily rates at Unst and Portsoy is $1^s,51$, and the loss from the 22d July to the 3d August, at this rate, is $18^s,12$. Hence we have Portsoy west of Unst $7^m.20^s,22$, and the longitude of Unst from Greenwich being $3^m.18^s,87$, we have the

longitude of Portsoy $10^m.39^s,09$ west of Greenwich. The mean of this, and the preceding result being $10^m.37^s,67$, is perhaps not many seconds distant from the truth. I must however remark, that from the variation in the rate of the chronometer, I do not rely upon these longitudes beyond the purpose to which they are to be applied, that of finding the sun's declination at apparent noon.

The instrument used for determining the latitudes, was the repeating circle, of one foot diameter, mentioned at the commencement of this Paper. Of the power of the repeating circle I had ever entertained the most favourable opinion; and I had now an opportunity of bringing it to the test of experiment, by connecting my stations with those of the trigonometrical survey, and comparing the latitudes obtained by the repeating circle with those deduced from observations made with the zenith sector.

As an error in latitude amounting to one minute, would not occasion a difference of one tenth of a vibration of the pendulum in 24 hours, I conceived it would have been an expense of time, which I could ill afford, to have waited for multiplied observations, except at certain stations, the latitudes of which I was anxious to ascertain with particular accuracy.

By the mean of numerous readings, I found the correction for the index error of my instrument to be $+ 18''$; and the value of each division of the large level to be $2,''4$.

In order to deduce the meridional zenith distance, from observations made near the meridian, I availed myself of a very convenient formula, for which I was indebted to Dr. YOUNG, and which has since been published, together with a small table of verse sines, by order of the Commissioners of

Longitude. The refractions and corrections for the barometer and thermometer, are taken from Dr. BRINKLEY's Tables, published with the observations made at the Royal Observatory at Greenwich.

In observations of the sun, the horary angle is estimated in solar time, but in those of the stars it must be expressed in sidereal time. It is most convenient, however, to employ the angle given by the chronometer in finding the correction of the apparent zenith distance, and afterwards to apply a further correction in the following manner.

Let r, be the daily loss of the chronometer on solar or sidereal time, according as the sun or star is observed; and let $r' = \frac{r}{86400 - r}$. Then calling the correction before found C, the final correction will be $(C + 2r'C)$. If the clock gain upon the star, C must be diminished by the quantity $2r'C$.

In using the repeating circle, it is of great importance that its plane should be truly vertical, or that its deviation should be known, in order to find the correction to be added on this account to the observed zenith distance. On my return to London, I found the error of my circle in this respect to be $4'.48''$, the correction for which may be obtained by the following formula:

$$\text{Sin.}\ \tfrac{1}{2}(z - z') = \frac{\text{sin.}^2 \tfrac{1}{2} \text{I.}}{\text{tang.}\ z'}$$

where z is the true zenith distance, z' the observed zenith distance, and I, the angle of inclination of the plane of the circle. In the second member of the equation, z may be taken $= z'$ without error. These formulæ, as well as many others respecting the repeating circle, is demonstrated by M. BIOT, in his valuable "Traité élémentaire d'Astronomie Physique."

At Unst, the following series of observations for the zenith distance of the sun's upper limb was made under the most favourable circumstances. The calculation of the latitude of this, as well as of the other stations, is given at length, to afford the opportunity of any examination that may be thought desirable.

UNST. 23d July, 1818. Barometer 30 inches, thermometer 61°. Time of apparent noon 0h.6m.2s,3. The chronometer too fast 47s,9. Time by the chronometer at apparent noon 0h.6m.50s,2.

Chronometer.	Level.		Time from Noon.	N. v. Sines.
h. m s.			m. s.	
23.49.39	+ 4	− 5	17.11	2809
23.51.46	+ 5	− 2	15. 4	2160
23.54.11	+ 3	− 3	12.39	1523
23.56.36	+ 2	− 3	10.14	0997
23.59.11	+ 4	− 1	7.39	0557
0. 1. 2	+ 4	− 0	5.48	0320
0. 3.29	+ 5	+ 2	3.21	0107
0. 6. 5	+ 3	− 1	0.45	0005
0. 9.41	+ 3	− 1	2.51	0077
0.11.23	+ 4	+ 3	4.33	0197
0.13.26	+ 4	+	6.36	0415
0.14.59	+ 4	+ 3	8. 9	0632
Mean	+ 45	− 5		0817

$\frac{(+45-5)}{2} \times 2'',4 = +48'',0$ correct. for the level.

Lat. 60°.45'.26" cosine	-	9.6888746
Dec. 20.10.57 cosine	-	9.9724798
Alt. 49.26.33 cos. co. ar.	-	0.1869458
Log. sine 1 co. ar.	- -	5.3144251
	Const. log.	5.1627253
	Log. 817 (+4)	6.9122221
	Corr. −118",83 log.	2.0749474

Readings, &c. ☉'s U.L.			
			° ' "
First Vernier	-		123.58.30,00
Second	- -	-	58. 0,00
Third	- -		57.55,00
Fourth	- -		58.10,00
Mean	-	-	123.58. 8,70
		+	360. 0. 0
Level	- -	+	0.48
Index	- -	+	0.18
			12)483.59.14,70
Observed Z. D.			40.19.56,22
Refract.		+	0.48,43
Paral.	- -	−	0. 5,67
Semidiam.		+	15.46,50
Correct.	-	−	1.58,83
Change of Dec.		+	0.2,16
(Z−Z')	-	+	0,24
True Z. D.			40.34.29,05
Dec.	- -	+	20.10.57,36
Lat. of Unst.	-		60.45.26,41

The spot where the above observations were taken, was that selected by M. Biot, the distance from which to the clock, measured on the meridian northward, was 182 feet $= 1,''79$.

Adding this to the observed latitude, we have $60°.45'.28'',2$ for the latitude of the station where the experiments with the pendulum were made.

The latitude of the spot where M. Biot's apparatus was fixed, and which was on the same parallel with mine, was determined by Lieut. Col. Mudge, by connecting it with his station on the island of Balta, where the zenith sector was erected, to be $60°.45'.29'',6$. But this latitude is dependent on that of Greenwich, which was taken at $51°. 28'. 40''$. By the observations however of the present Astronomer Royal, and the use of the French refractions, which are very nearly the same as those of Dr. Brinkley, the latitude of Greenwich appears to be $51°.28'.38'',01$, or $1'',99$ less than by former observations. This quantity being subtracted from Col. Mudge's determination, we have $60°.45'.27'',61$ for the latitude of the pendulum at Unst, deduced from the Trigonometrical Survey, and $60°.45'.28'',2$ by one series of zenith distances of the sun, taken with the repeating circle.

Latitude of Portsoy.

The following series of zenith distances of the sun's upper limb, was taken at the bottom of Mr. Watson's garden.

PORTSOY, 3d Aug. 1818. Barometer 30 inches, thermometer 65°. Time of apparent noon $0^h.5^m.51^s$. The chronometer too fast $7^m.52^s.58$. (See Appendix.) Time by the Chronometer at apparent noon $0^h.13^m.43^s,58$.

Chronometer.	Level.		Time from Noon.	N. v. Sines.
h. m. s.			m. s.	
0. 5.23	+ 3	+ 6	8.21	0664
0. 7.16	+ 4	+ 5	6.28	0398
0. 9. 8	+ 5	+ 7	4.36	0201
0.10. 7	+ 2	+ 3	3.37	0124
0.12.17	+ 4	+ 7	1.27	0020
0.13.36	— 5	— 3	0. 8	0000
0.15.43	— 10	— 6	1.59	0037
0.17.38	— 6	— 4	3.54	0145
0.20.36	+ 7	+ 9	6.52	0449
0.22.30	— 9	— 7	8.46	0732
0.24.58	+ 1	+ 3	11.14	1201
0.26 42	— 7	— 4	12.58	1600
Mean .	— 11	+ 16		464

$\frac{(-11+16)}{2} \times 2{,}4'' = +6''$ correction for the level.

	° ′ ″			
Lat.	57.40.57	cosine	-	9.7280375
Dec.	17.37.50	cosine	-	9.9791062
Alt.	49.56.53	cos. co. ar.	-	0.1914637
Log. sin.	1	co. ar.	-	5.3144251
			Const. Log.	5.2130325
			Log. 464 (+4)	6.6665180
			Cor. —75″,78 Log.	1.8795505

Readings, &c. ☉'s U. L.

		° ′ ″
1st Vernier	-	117.35.15,00
Second	- -	34.35,00
Third	- -	34.20,00
Fourth	- -	34.35,00
Mean	- -	117.34.41,25
	+	360. 0. 0,00
Level	. +	0. 0. 6,00
Index	- - +	0. 0 18,00
	12)	477.35 5,25
Observed Z. D.	-	39.47 55,44
Refract.	- +	0.46,43
Paral.	- —	0. 5,61
Semidiam.	- +	15.47,77
Correct	- —	1.15,78
Change of Dec.	—	0. 1,15
(Z—Z′)	+	0,26
True Z. D.		40. 3. 7,36
Dec.	+	17.37 50,03
Lat. of Portsoy.		57.40.57,39

The distance from the place where the latitude was determined to the pendulum, measured on the meridian, was 129 feet, which is equal to 1″,26.

This being added to the observed latitude we obtain 57°.40′.58″,65 for the latitude of the pendulum.

In order to deduce my latitude from that of Cowhythe, a station was chosen on a small eminence called Portsoy Hill,

294 feet north of the spot where my observations for latitude were made. At this station the oblique angle between Cowhythe and Knock Hill was observed by four repetitions

to be - - - - -		117°.56′.50″,44
The zenith distance of Cowhythe -		88. 38. 40
——————— of Knock Hill -		83. 8. 51
Whence the angle between Cowhythe and Knock Hill, reduced to the horizon, is - -		118.°21′.35″,64
Cor. for the excentricity of the telescope	+	1, 70
True horizontal angle -		118. 21. 37, 34

The station at Cowhythe is marked by a conical mass of masonry, which obliged me to place the instrument at the distance of eight feet from its centre, in the direction of Portsoy Hill.

The oblique angle at this spot between Knock Hill and

Portsoy Hill, was - - -		54°.23′. 3″
The zenith distance of Knock Hill - -		88. 30. 25
——————— of Portsoy Hill -		91. 23. 30
Hence the angle between Knock Hill and Portsoy Hill, reduced to the horizon, is - - -		54°.18′.49″
Reduction to the centre of the station -	—	31,5
Cor. for the excentricity of the telescope	—	1,7
True horizontal angle -		54. 18. 15,8

The distance from Cowhythe to Knock Hill, by the trigonometrical survey, is 42633 feet, Knock Hill being to the south west 31°.57′.8″. We have then the following triangle to determine the distance from Cowhythe to Portsoy Hill:

Cowhythe	$54°.18'.15'',8$	to Portsoy Hill	6182
Knock Hill	$7.20.\ 6,9$		——
Portsoy Hill	$118.21.37,3$		

If the angle at Cowhythe be added to $31°.57'.8''$, we have $86°.15'.23'',8$ for the bearing of Portsoy Hill, to the south-west from Cowhythe, from which and the distance of Cowhythe from Portsoy Hill, we obtain 404 feet for the distance of Portsoy Hill to the south on the meridian.

The latitude of Cowhythe, by the Trigonometrical Survey, is $57°.41'.11''$ from which deducting $4'',02$ for the distance on the meridian, $1'',99$ the error of the former latitude of Greenwich, and $2'',92$ the arc due to 294 feet, we obtain $57°.41'.2'',07$ for the latitude of my station, deduced from that of Cowhythe, and differing $4'',68$ in excess from the latitude given by the Repeating Circle.

These observations for connecting my station with Cowhythe were made under various unfavourable circumstances, and indeed I am not quite sure that the object I took on Knock Hill was in fact the station; for a pole originally placed in the centre of a cone of masonry, as at Cowhythe, has been taken away, and it was some time before I could decide which to choose among two or three eminences resembling each other, which happen to be upon the hill. The preceding result therefore can be considered only as a proof that no error of consequence is to be feared in my determination of the latitude of Portsoy.

Latitude of Leith Fort.

At Leith Fort, the two following series of observations were made, the sun being frequently obscured by flying clouds.

The first station was at the Flag staff, the second station 43 feet to the south of it.

Leith Fort, 13th September 1818. Barometer 30,25 inches, thermometer 62°. Time of apparent noon $23^h.55^m57^s,2$. The chronometer too fast $8^m.49^s,58$. (See Appendix.) Time by the chronometer at apparent noon $0^h.4^m.46^s,78$.

Chronometer.	Level.		Time from Noon.	N. v. sines.
h. m. s.			m. s.	
23.55.25	+ 3	— 5	9.22	0835
23.58.39	+ 1	— 7	6. 8	0358
0. 1.47	+ 7	— 0	3. 0	0086
0. 4.20	+ 5	— 3	0.27	0002
0.14.16	+ 6	— 7	9.29	0856
0.16.17	+ 7	— 6	11.30	1259
Mean	+ 29	— 28		566

$\frac{(+29-28)}{2} \times 2'',4 = -1'',2$ correct. for the level.

Lat. 55°.58′.41″ cosine	-	9.7478082
Dec. 3.56.28 cosine	-	9.9989718
Alt. 37.57.47 cosine co. ar.		0.1032492
Log sin, 1 co. ar.	-	5.3144251
Const. log.		5.1644574
Log. 566 (+4)		6.7528164
Cor.— 82″66 Log.		1.9172738

Readings, ☉'s U. L.			
1st. Vernier	-		310°.39′.15″
Second	-	-	38.50
Third	-	-	38.50
Fourth	-	-	38.55
Mean	-	-	310.38.57,50
Level	-	—	1,23
Index	-	+	18,00
			6)310.39.14,30
Observed Z. D.	-		51.46.32,38
Refract.		+	1.12,78
Paral.	-	—	6,88
Semidiam.	-	+	15.56,20
Correct.	-	—	1.22,66
Change of Dec.		+	0. 1,28
(Z—Z′)		+	0,16
True Z. D.	-		52. 2.13,26
Dec.	-	+	3.56.27,74
Lat. of the Flag Staff.			55.58.41,00

LEITH FORT, 17th Sept. 1818. Barometer 30,05 inches, thermometer 66°. Time of apparent noon $23^h.54^m.32^s,8$. The Chronometer too fast $8^m.42^s,18$ (see Appendix.) Time by the chronometer at apparent noon $0^h.3^m.14^s,98$.

Chronometer.	Level.		Time from Noon.	N. v. Sines.
h. m. s.			m. s.	
23.52.28	+ 14	— 7	10.47	1107
23.54.21	+ 10	— 10	8.54	0754
0.10. 6	+ 25	— 0	6.51	0447
0.11.26	+ 10	— 15	8.11	0637
0.13. 6	+ 23	— 0	9.51	0923
0.14.19	+ 7	— 15	11. 4	1166
Mean .	+ 89	— 47		839

$\frac{(+89''-47'')}{2} \times 2,4 = +50'',4$ correct. for the level.

Lat.	55°.58′.41″	cosine -	9.7478082
Dec.	2.24. 2	cosine - -	9.9996187
Alt.	36.25.20	cosine co. ar. -	0.0943857
Log. sin.	1	co. ar. -	5.3144251
		Const. Log.	5.1562377
		Log. 839 (+4)	6.9237620
		Corr. —120″,23 Log.	2.0799997

Readings, &c. ☉'s U. L.

		° ′ ″
1st Vernier -		319.56 45
Second - -		30
Third - -		30
Fourth - -		15
Mean - -		319.56.30
Level - -	+	50,40
Index - -	+	18,00
		6) 319.57.38,40
Observed Z. D.	·	53.19.36,40
Refract. -	+	1.15,85
Paral. - -	—	7,03
Semidiam - -	+	15.57,27
Correct. - -	—	2. 0,23
Change of Dec.	—	2,63
(Z—Z′)	+	0,15
True Z. D.		53.34.39,76
Dec.	+	2.24. 1,63
		55.58.41,39
Deduct. for diff. of Stations, (43 ft.)	—	0,43
Lat. of the Flag Staff		55.58.40,96

By the Trigonometrical Survey, the latitude of the Flag staff of Leith Fort, is 55°.58′.41″, but from this 1″,99 must be subtracted as before. We have then 55°.58′.39″,01 for the latitude of the Flag staff, from which that obtained by the repeating circle under unfavourable circumstances differs 1″,97 in excess.

The distance of the clock from the Flag staff was 180 feet to the north, and the corresponding arc 1″,8 being added

to $55°.58'.39''$, we have $55°.58'.40'',8$ for the latitude of the pendulum.

Latitude of Clifton.

In " an account of the measurement of an arc of the meridian," by Lieut. Col. MUDGE, a singular anomaly presents itself, which since the year 1802, when this measurement was made, has been considered with much interest, and in various points of view by the scientific world. Instead of the degrees of the meridian *increasing* with the latitude, as is the case in an oblate spheroid, they appear by this measurement to *decrease*. This remarkable circumstance was examined by Don JOSEPH RODRIGUEZ, in an ingenious paper published in the Philosophical Transactions for 1812. The author proceeding according to a method of verification given by M. DELAMBRE in the " Base Métrique," calculates upon the elliptic hypothesis the length of the whole arc and of each of its parts in seconds, and from the observed latitude of Clifton, the northern extremity of the arc, deduces that of Dunnose, the southern extremity, and of Arbury Hill, an intermediate station which divides the total arc into two nearly equal parts. Don JOSEPH RODRIGUEZ then compares the celestial arcs given by Col. MUDGE's observations, with those resulting from his own calculations, and concludes that the total *observed* arc between Clifton and Dunnose is in excess $1'',38$; that, between Clifton and Arbury $4'',77$; and that the southern portion of the arc between Arbury Hill and Dunnose, is $3'',39$ in defect. The author adds, that " it seems almost beyond a " doubt, that it is to errors in the observations of latitude, " that the appearance of progressive augmentation of degrees " towards the equator is to be ascribed," and that " it is espe-

"cially at the intermediate station at Arbury Hill, that the "observations of the stars are erroneous nearly 5″, notwith-"standing the goodness of the instruments and the skill and "care of the observer."

An error at Arbury Hill amounting to 5″, could scarcely be supposed possible with such an instrument as the zenith sector, in the hands of Col. MUDGE; and the less so, from its appearing that the latitude of Blenheim, deduced trigonometrically from that of Arbury Hill, differed only a fraction of a second from the latitude obtained by the observations made with RAMSDEN's quadrant at Blenheim observatory. On the other hand, it is not surprising that so great a deviation of the plumb line from the vertical as 5″,* which would indicate the existence of a disturbing force very nearly equal to that exerted by the mountain Schehallion, should be received with much caution. It became therefore very desirable to endeavour to throw some light on this interesting question, by additional observations at Clifton, Arbury Hill, and Dunnose, for the latitudes of those important stations, an operation to which I felt confident that my repeating circle would not be found inadequate.

Before I proceed to detail the observations made at Clifton, I must observe, that in the repeating circle, as usually constructed in England, the level turns on the axis, and when clamped, is carried with the circle, which renders an additional operation necessary at each repetition, to bring back the level to its former horizontal position. Imagining that if I could obviate this, it would be a considerable saving of time, I had a

* The weight of the plumb line is drawn towards the *north* and not to the *south*, as is stated by Col. MUDGE, who probably meant to express the direction of the inclination from the vertical.

contrivance executed at Edinburgh, by which I could fix the level very firmly in its horizontal position to the pillar of the instrument. This being done, the following observations were made for the zenith distance of the pole star. The corrections for precession, &c. are those used at the Royal Observatory at Greenwich, and the mean polar distance of the pole star is that resulting from the latest observations of the Astronomer Royal.

The transit instrument was within one second in time of the meridian, the error of the chronometer was therefore deduced from the passage of the sun.

CLIFTON, 3d October, 1818. Barometer 29,20 inches, thermometer 44°, chronometer too fast $5^s,15$. Pole star on the meridian by the chronometer $12^h.8^m.48^s,5$.

Chronometer.	Level		Time from the meridian.	N. v. Sines.	Readings, &c.	
h. m. s.			m. s.			° ′ ″
11.54.24	+ 20	— 16	14.25	1978	1st Vernier -	348.44. 0
11.58. 9	+ 7	— 30	10.40	1083	Second - -	43.50
12. 1.17	+ 9	— 31	7.32	0540	Third - -	43.37
12. 6.12	+ 20	— 20	2.37	0065	Fourth - - -	43.25
12.10.16	+ 18	— 20	1.27	0020		
12.14.15	+ 11	— 26	5.26	0281	Mean - -	348.43.43
12.16.55	+ 16	— 23	8. 6	0624	Level - - —	1.41,6
12.20. 0	+ 7	— 30	11.11	1190	Index - - +	0.18,0
12.24.12	+ 19	— 20	15.23	2252		
12.27.10	+ 4	— 33	18.21	3204	10)	348.42.19,5
Mean -	+131	—249		1124	Observed Z. D. -	34.52.13,94
					Refract. - +	40,14
					Correct. - —	7,03
					$2r'C.$ —	0,04
					$(Z-Z')$ +	0,30

$$\frac{+131-249}{2} \times 2'',4 = -1'.41'',6 \text{ correct. for level.}$$

Lat.	53°.27′.41″	cosine - -	9.7747828
Dec.	88.20.28	cosine - -	8.4616340
Alt.	55. 7.13	cosine co. ar. -	0.2427136
Log. sin.	1	co. ar. -	5.3168000
		Const. Log.	3.7959304
		Log. 1124 (+4)	7.0507663
		Correct. —7″,026 Log.	0.8466967

True Z. D.	34.52.47,31
Mean PD. for 1818 +	1.39.44,15
Precession, &c. - —	12,40
Co. Lat.	36.32.19,06
Lat. of Clifton	53.27.40,94

CLIFTON, 5th October, 1818. Barometer 29,0 inches, thermometer 42°, chronometer too fast 2s,8. Pole star on the meridian by the chronometer, 12h.0m.54s,4.

Chronometer.	Level.		Time from the meridian.	N. v. Sines.
h. m. s.			m. s.	
11.39.20	+ 32	— 24	21.34	4424
11.45.11	+ 16	— 39	15.43	2350
11.51.10	+ 26	— 33	9.44	0902
11.55.13	+ 30	— 29	5.41	0307
11.58.10	+ 26	— 34	2.44	0071
12. 1.50	+ 31	— 29	0.56	0008
12. 5.28	+ 25	— 36	4.34	0198
12. 8.17	+ 32	— 29	7.23	0519
12.12.55	+ 36	— 24	12. 1	1374
12.16.10	+ 23	— 37	15.16	2218
12.18.50	+ 24	— 38	17.56	3060
12.25.10	+ 27	— 34	24.16	5600
	+328	—386		175

$\frac{(+328-386)}{2} \times 2'',4 = -69'',6$ cor. for the level.

Const. Log.	- -	3.7959304
Log. 1753 (+4)	- -	7.2437819
Cor. —10″,96 Log.	-	1.0397123

Readings, &c.

			° ′ ″
1st Vernier	-		58.27.50
Second	- -	-	40
Third	-	-	10
Fourth	-	-	35
Mean	-	-	58.27.33,75
		—	360. 0. 0
Level	-	- —	1. 9,60
Index	.	- +	0.18,00
		12)	418.26.42,15
Observed Z. D.	-		34.52.13,51
Refract.	-	- +	40,03
Correct.	-	- —	10,96
2 r′C.	-	—	0,06
(Z—Z′)	-	+	0,30
True Z. D.	-		34.52.42,82
Mean P. D. for 1818		+	1.39.44,15
Precession, &c.	-	—	13,17
	Co. Lat.		36.32.13,80
	Lat. of Clifton		53.27.46,20

Clifton, 6th October, 1818. Barometer 29,20 inches, thermometer 42°, chronometer too fast $1^s,0$. Pole star on the meridian by the chronometer $11^h.56^m.56^s,7$.

Chronometer.	Level.		Time from the meridian.	N. v. Sines.
h. m. s.			m. s.	
11.33.50	+ 30	— 21	23. 7	5083
11.38.33	+ 24	— 29	18.24	3821
11.41.25	+ 4	— 53	15.32	2296
11.44.25	+ 43	— 12	12.32	1495
11.46.53	+ 17	— 39	10. 4	0964
11.50.15	+ 41	— 15	6.42	0427
11.53. 5	+ 24	— 30	3.52	0142
11.56.25	+ 37	— 19	0.32	0003
11.59.23	+ 30	— 25	2.26	0056
12. 1.55	+ 32	— 25	4.58	0235
12. 5.25	+ 36	— 18	8.28	0682
12. 8. 5	+ 27	— 30	11. 8	1180
12.11.15	+ 14	— 44	14.18	1946
12.14.43	+ 41	— 15	17.46	3003
12.17.25	+ 26	— 30	20.28	3985
12.21. 0	+ 40	— 17	24. 3	5501
Mean -	+466	—422		1888

$\frac{(+466-422)}{2}'' \times 2,4 = +52,8''$ cor. for the level.

Const. Log.	- -	3.7959304
Log. 1888 (+4)	- -	7.2760020
Correct.—11″,80 Log.	-	1.0719324

Readings, &c.

			° ′ ″
1st Vernier	-		197.55.50
Second	- -		25
Third	- -		20
Fourth	- -		50
Mean	- -		197.55.36,25
		+	360. 0. 0
Level	- -	+	52,80
Index	- -	+	18,00
		16)	557.56.47,05
Observed Z. D.	-		34.52.17,94
Refract.	- -	+	40,31
Correct.	- -	—	11,80
2 r′C.	-	—	0,06
(Z—Z′)	-	+	0,30
True Z. D.	-		34.52.46,69
Mean P. D. for 1818		+	1.39.44,15
Precession, &c.	-	—	13,56
Co. Lat.			36.32.17,28
Lat. of Clifton	-		53.27.42,72

On comparing the three preceding results, a difference may be perceived between them amounting to 5″,24; and as I felt assured that the principle of the repeating circle was too perfect to allow of an error of this magnitude, a little reflection led me to discover the cause, to be my fancied improvement in fixing the level to the pillar of the instrument. For in turning the telescope on its axis, the friction, however slight it may be, tends to disturb the relative position of the circle

and level, and thus to introduce error. In the usual construction the level may be clamped to the circle, and then it moves with it without any risk of derangement. This construction was indispensable, in order that the instrument might be used for taking terrestrial angles, and it is to this, perhaps originally accidental circumstance, that the repeating circle is indebted for its very near approach to perfection. After I had restored the instrument to its former state, the following observations were made.

CLIFTON, 8th October, 1818. Barometer 29,60 inches, thermometer 46°. Chronometer too slow 2s,9. Pole star on the meridian by the chronometer 11.h49m.1s.

Chronometer.	Level.		Time from the meridian.	N. v. Sines.
h. m. s.			m. s.	
11.22.10	+ 23	— 24	26.51	6855
11.25.35	+ 26	— 23	23.26	5223
11.30.20	+ 24	— 24	18.41	3321
11.33.12	+ 24	— 24	15.49	2380
11.37.10	+ 21	— 27	11.51	1336
11.40.12	+ 24	— 25	8.49	0740
11.44. 7	+ 22	— 28	4.54	0229
11.48.10	+ 24	— 25	0.51	0007
11.53.30	+ 24	— 25	4.29	0191
11.57. 0	+ 26	— 24	7.59	0607
12. 0.10	+ 29	— 19	11. 9	1183
12. 3. 8	+ 22	— 28	14. 7	1896
12. 6.37	+ 27	— 22	17.36	2947
12. 9.23	+ 23	— 28	20.22	3946
	+339	—346		2204

$\frac{(+339-346)}{2} \times 2'',4 = -8'',4$ cor. for the level.

Const. Log.	- -	3.7959304
Log. 2204 (+4)	- -	7.3432116
Correct.—13″,78 Log.	-	1.1391420

Readings, &c.		° ′ ″
1st Vernier	- -	128.13. 0
Second	- -	12.30
Third	- -	12.25
Fourth	- -	12.35
Mean	- -	128.12.37,5
	+	360. 0. 0
Level	- - —	8,4
Index	- - +	18,0
	14)	488.12.47,1
Observed Z. D.	-	34 52.20,51
Refract.	- - +	40,52
Correct.	- - —	13,78
2r′C.	- —	0,08
(Z—Z′)	- +	0,30
True Z. D.	-	34.52.47,47
Mean P. D. for 1818	+	1.39.44,15
Precession, &c.	- —	14.34
Co. Lat.	-	36.32.17,28
Lat. of Clifton		53.27.42,72

Clifton, 12th October, 1818. Barometer 29,56 inches, thermometer 47°, chronometer too slow 9s,0. Pole star on the meridian by the chronometer 11h.33m.11,6.

Chronometer.	Level.		Time from the meridian.	N. v. Sines.
h. m. s.			m. s.	
11.12.40	+ 22	— 26	20.32	4011
11.16.55	+ 26	— 22	16.17	2523
11.21.10	+ 24	— 24	12. 2	1378
11.24.25	+ 25	— 24	8.47	0734
11.27.45	+ 25	— 23	5.27	0283
11.31. 0	+ 25	— 25	2.12	0046
11.34.15	+ 28	— 21	1. 3	0010
11.37.25	+ 25	— 24	4.13	0169
11.41.12	+ 24	— 24	8. 0	0609
11.43.15	+ 25	— 24	10. 3	0961
11.47.47	+ 25	— 22	13.35	1756
11.50.38	+ 25	— 25	17.26	2892
11.54. 5	+ 25	— 23	20.53	4149
11.56.16	+ 26	— 24	23. 4	5061
	+350	—331		1755

$\frac{(+350-331)}{2} \times 2'',4 = +22'',8$ cor. for the level.

Const. Log. - -	3.7959304
Log. 1755 (+4) - -	7.2442771
Correct.—10″,97 Log. -	1.0402075

Readings, &c.

		° ′ ″
1st. Vernier - -		128.12. 0
Second - - -		11.30
Third - -		11.35
Fourth - -		11.25
Mean - - -		128.11.37,5
-	+	360. 0. 0
Level - -	+	22,8
Index - -	+	18,0
	14)	488.12.18,3
Observed Z. D. -		34.52.18,45
Refract. - -	+	40,38
Correct. - -	—	10,97
2 r′C. -	—	0,06
(Z—Z′) -	+	0,30
True Z. D. -		34.52.48,10
Mean P. D. for 1818	+	1.39.44,15
Precession, &c. -	—	15,92
Co. Lat. -		36.32.16,33
Lat. of Clifton		53.27.43,67

The preceding results in one view are as follow:

	° ′ ″
	53.27.40,94
	53.27.46,20
	53.27.42,72
	53.27.42,72
	53.27.43,67
Mean	53.27.43,25

K

The difference between the two last results which were obtained after the instrument was restored to its original state, is not one second, and the mean of the three first differs only 0″,05, and of the two last results 0″,06 from the mean of the whole.

The station where the latitude was observed, was nine feet to the north of the chimney of the room in which the clock was placed; and allowing four feet for the distance of the clock from the chimney, we have 53°.27′.43″,12 for the latitude of the pendulum.

The distance of Laughton Spire from Clifton Beacon, by the Trigonometrical Survey, is 25409 feet, and its bearing 1°.56′.12″ to the south-west. With these data, and the angles observed on the azimuth circle of my instrument, and given in the Appendix, the distance on the meridian, from Clifton Beacon to the chimney of the room where the clock was placed, was found to be 1346 feet, to which nine feet being added, and the arc 13″,36 corresponding to this distance subtracted from the latitude before found, we have 53°.27′.29″,89 for the latitude of Clifton Beacon.

Before I availed myself of the distance of Laughton spire from Clifton Beacon, I had measured a base of 797 feet for the same purpose, and this gave the distance of the chimney from Clifton Beacon on the meridian 1323 feet; but as I could not see the same part of the chimney from both ends of the base, this determination serves merely to check that before given, and to render it highly probable that there cannot be an error of 10 feet, and perhaps not near so much in the distance first stated.

The observed arc between Greenwich and Clifton Beacon,

by the Trigonometrical Survey, is 1°.58.′51″,59, and this being added to 51°.28′.38″,01 (the latitude of Greenwich) gives 53°.27′.29″,60 for the latitude of Clifton Beacon, differing only 0″,29 in defect, from the result obtained by the repeating circle, and affording, it is presumed, a satisfactory proof (as far as this instrument is entitled to credit) of the accuracy of the observations made with the zenith sector, both at Clifton Beacon and at Greenwich.

Latitude of Arbury Hill.

The season was so far advanced when I arrived at this important station, that I could not expect numerous observations for the latitude; but from the near agreement of the results at Clifton, I was encouraged to hope that the observations at Arbury Hill, though few in number, might prove satisfactory.

The bell tent was pitched on the *old* station of the Trigonometrical Survey, where the theodolite was placed. This spot may be readily ascertained from Col. MUDGE's description, to within 10 feet. Pickets were driven into the ground, on which rested the legs of a very stout triangular stand, which served as a support to the Repeating Circle. Every precaution which I could think of was used to ensure accuracy. The instrument was adjusted, the telescope directed to the star, and the whole left for nearly half an hour before the commencement of the observations, in order that it might acquire an equal temperature. When the wire was brought very nearly to bisect the star, the tangent screw was turned a little in an opposite direction to release it from any strain, and the hand being withdrawn, the star was watched until its bisection was perfect. The time was then noted, and the level carefully

read off by the non-commissioned officer and myself, without either of us moving from the place where we stood. In this manner the three following series of observations were made. The error of the chronometer was determined by altitudes of the sun given in the Appendix, and its daily rate was $1^s,26$.

ARBURY HILL, 18th October, 1818. Barometer 29,40 inches, thermometer $48^\circ,5$. Chronometer too slow $14^s,7$. Pole star on the meridian by the chronometer $11^h.9^m.29^s,9$.

Chronometer.	Level.		Time from the meridian.	N. v. Sines.
h. m. s.			m. s.	
10.48.35	+ 22	— 22	20.55	4162
10.53. 5	+ 23	— 22	16.25	2564
10.57.40	+ 21	— 24	11 53	1344
11. 1.38	+ 24	— 21	7.52	0589
11. 5. 2	+ 24	— 21	4.28	0190
11. 8. 0	+ 21	— 24	1.30	0021
11.11.23	+ 25	— 19	1.53	0034
11.14.22	+ 20	— 25	4.52	0226
11.18.55	+ 24	— 21	9.25	0844
11.21.55	+ 18	— 26	12.25	1467
11.24.55	+ 23	— 21	15.25	2262
11.27.10	+ 21	— 25	17.40	2970
11.30.47	+ 24	— 21	21.17	4309
11.33.30	+ 22	— 23	24. 0	5478
	+312	—315		1890

$\frac{(+312-315)}{2} \times 2{,}4'' = -3'',6$ cor. for the level.

Lat. 52.13.26 cosine	-	9.7871611
Dec. 88.20.30 cosine	-	8.4614886
Alt. 53.52.50 cosine co. ar.		0.2295379
Log. sin. 1 co. ar.	- -	5.3168000
Const. Log.		3.7949876
Log. 1890 (+4)		7.2764618
Correct.—11'',79 Log.		1.0714494

Readings, &c.

		° ′ ″
1st. Vernier	- -	145.32.57
Second	- -	20
Third	- -	30
Fourth	- -	35
Mean	- -	145.32.35,5
		+360, 0. 0
Level	- - —	3,6
Index	- - +	18,0
	14)	505.32.49,90
Observed Z. D.	-	36. 6.37,85
Refract.	- - +	41,90
Correct.	- - —	11,79
2 r′C.	- —	0,05
(Z—Z′	- +	0,28
True Z. D.	- +	36. 7. 8,19
Mean P. D. for 1818	+	1.39.44,15
Precession, &c.	- —	18,23
Co. Lat.	-	37.46.34,11
Lat. of Arbury Hill		52.13.25,89

ARBURY HILL, 22d October, 1818. Barometer 29,40 inches, thermometer 45° Chronometer too slow 19s,7. Pole star on the meridian by the chronometer $10^{h}.53^{m}.40^{s},7$.

Chronometer.	Level.		Time from the meridian.	N. v. Sines.
h. m. s.			m. s.	
10.37. 5	+ 24	— 24	16.36	2622
10.40.15	+ 23	— 25	13.26	1717
10.44.45	+ 25	— 23	8.56	0760
10.49.27	+ 24	— 24	4.14	0171
10.53.25	+ 28	— 19	0.16	0001
10.57.45	+ 26	— 23	4. 4	0157
11. 1.18	+ 28	— 19	7.37	0552
11.14.45	+ 24	— 24	21. 4	4222
11.17.25	+ 27	— 21	23.44	5357
11.19.30	+ 25	— 24	25.49	6338
	+254	—226		2190

$\frac{(+254-226)}{2} \times 2'',4 = +33'',6$ cor. for the level.

Const. Log.	- -	3.7949876
Log. 2190 (+4)	- -	7.3404441
Correct. —13″,66 Log.		1.1354317

Readings, &c.

		° ′ ″
1st Vernier	- -	361. 6.30
Second	- -	6.25
Third	-	6. 0
Fourth	- -	5.55
Mean	- -	361. 6.12,5
Level	- +	33,6
Index	- - +	18,0
		10) 361. 7. 4,10
Observed Z. D.	-	36. 6.42,04
Refract.	- +	42,23
Correct.	- - —	13,66
2 r′C.	- —	0,08
(Z—Z′)	- +	0,28
True Z. D	-	36. 7.10,81
Mean P. D. for 1818	+	1.39.44,15
Precession, &c.	- —	19,72
Co. Lat.	-	37.46.35,24
Latitude of Arbury Hill		52.13.24,76

The night very clear, but flying clouds.

ARBURY HILL, 26th October, 1818. Barometer 29,52 inches, thermometer 47°,5. Chronometer too slow 24ˢ,74. Pole star on the meridian by the chronometer 10ʰ.37ᵐ.52ˢ,02

Chronometer.	Level.		Time from the meridian.	N. v. Sines.
h. m. s.			m. s.	
10.15.15	+ 22	— 22	22.37	4865
10.18.40	+ 20	— 24	19.12	3507
10.23. 0	+ 23	— 21	14.52	2103
10.25.43	+ 23	— 21	12. 9	1405
10.30.27	+ 21	— 23	7.25	0524
10.34. 5	+ 22	— 23	3.47	0136
10.37.20	+ 22	— 22	0.32	0003
10.39.50	+ 22	— 22	1.58	0037
10.43.15	+ 24	— 20	5.23	0276
10.47. 5	+ 20	— 24	9.13	0809
10.50.52	+ 24	— 20	13. 0	1608
10.53.25	+ 20	— 24	15.33	2301
10.57.32	+ 24	— 20	19.40	3680
11. 0.32	+ 20	— 24	22.40	4887
	+307	—310		1867

$\frac{(+307-310)}{2} \times 2'',4 = -3'',6$ cor. for the level.

Const. Log.	-	3.7949876
Log. 1867 (+4)	-	7.2711443
Correct. -11″,64 Log.	-	1.0661319

Readings, &c.		
		° ′ ″
1st Vernier -	-	145.33.38
Second -	-	33. 3
Third -	-	33.15
Fourth -	-	33.18
Mean -	-	145.33.18,50
	+	360. 0. 0
Level -	- —	3,60
Index -	- +	18,00
	14)	505.33.32,90
Observed Z. D.		36. 6.40,92
Refract. -	- +	42,15
Correct. -	- —	11,64
2 r′C. -	—	0,06
(Z—Z′) -	+	0,28
True Z. D. -		36. 7.11,65
Mean P. D. for 1818	+	1.39.44,15
Precession, &c.	- —	21,30
Co. Lat.		37.46.34,50
Latitude of Arbury Hill		52.13.25,50

The mean of the three preceding results is 52°.13′.25″,38, and the greatest difference 1″,13.

In the "Account of the Trigonometrical Survey," Col. MUDGE states, that the zenith sector was put up 34 feet to the north, and 28 feet to the west of the old station at Arbury Hill; therefore 0,34″ must be added, on this account, to obtain 52°.13′.25″,72, the latitude of the spot where the zenith sector was placed.

The observed arc between Greenwich and Arbury Hill, is $0^\circ.44'.48'',19$, which being added to the latitude of Greenwich, gives $52^\circ.13'.26'',20$ for the latitude of Arbury Hill by the Trigonometrical Survey, which differs $0'',48$ *in excess*, from the latitude given by the Repeating Circle.

We cannot then but conclude, that the observations made with the zenith sector, both at Clifton and Arbury Hill, are free from any material error; and as the difference between the latitudes of Clifton by the Zenith Sector, and by the Repeating Circle, was $0'',29$, that by the Zenith Sector being *in defect*, and of Arbury Hill $0'',48$ *in excess*, it is extremely probable that the error of observation at either of these stations does not amount to so much as four-tenths of a second.

A base of 906 feet was carefully measured near the foot of Arbury Hill, for the purpose of finding the distance on the meridian of this station from the pendulum; which distance, as appears in the Appendix, was 3048 feet, the pendulum being so nearly in the meridian of the station, that no deduction on account of its bearing is necessary. The arc corresponding to 3048 feet, is $30'',06$, which being subtracted from $52^\circ.13'.25',32$, leaves $52^\circ.12'.55'',32$ for the latitude of the pendulum.

Latitude of the Station at London.

The latitude of Mr. Browne's house in Portland Place, deduced from the Trigonometrical Survey, as detailed in the Philosophical Transactions for 1818, is $51^\circ.31'.8'',4$.

Latitude of Shanklin Farm.

Having observed for the latitude of Arbury Hill, at the station itself, it was my intention to have done the same at Dunnose, but this, from the distance of the station, and the difficulty of the ascent, I found impracticable. My observations therefore were made on a spot which was 20 feet south of the chimney of the summer-house in which the pendulum was placed. Previously to quitting London, the transverse level of the repeating circle was adjusted so as to render any correction unnecessary, and the axis carrying the telescope having been tightened, the index error was again carefully determined, and found to be 13″. The observations were made under circumstances peculiarly favourable, and though those forming the second series are few in number, in consequence of the pole star having been frequently obscured by light clouds, I consider them as unexceptionable. The correction of the mean polar distance for precession, &c. was kindly supplied by the Astronomer Royal.

By altitudes of the sun, given in the Appendix, the chronometer was fast on the 10th of May $4^m.39^s,7$, its daily rate being $-1'',78$.

Shanklin Farm, May 13th, 1819. Barometer 30,14 inches, thermometer 47°,0. Chronometer too fast $4^{m}.45^{s}$. Pole star on the northern meridian by the chronometer $9^{h}.37^{m}.32^{s}$. Mean polar distance for 1819, 1°.39′.24″,70.

Chronometer.	Level.		Time from from the meridian.	N. v. Sines.	Readings, &c.			
h. m. s.			m. s.					° ′ ″
9.13.15	+ 31	— 10	24.17	5608	1st Vernier	-	-	214.14.32
9.16.40	+ 8	— 34	20.52	4142	Second	-	-	20
9.21.21	+ 21	— 22	16.11	2492	Third	-	-	10
9.33.55	+ 17	— 24	3.37	0124	Fourth		-	40
9.36 44	+ 21	— 21	0.48	0006				
9.39.55	+ 21	— 21	2.23	0054	Mean	-	-	214.14.25,5
9.42.27	+ 22	— 19	4.55	0230				+360. 0. 0
9.45.40	+ 23	— 20	8.08	0630	Level	-	-	0
9.48.56	+ 20	— 22	11.24	1237	Index	-	+	13,0
9.51.53	+ 25	— 18	14.21	1960				
9.54.40	+ 20	— 21	17.08	2793				4)574.14.38,5
9.56.48	+ 19	— 22	19.16	3531				
9.59.40	+ 21	— 21	22 08	4660	Observed Z. D.		-	41. 1. 2,75
10. 2.20	+ 24	— 18	24.48	5849	Refract.	-	+	51,35
					Correct.	-	+	13,80
	+293	+293		2379	2 r′C.	-	+	0,08

° ′ ″		True Z. D. -	41. 2. 7,98
Lat. 50.37.24 cosine - -	9 8023740	App. P. D. - —	1.39.31,13
Dec. 88.20.29 cosine - -	8.4615613		
Alt.. 48.57.52 cosine co. ar. -	0.1827472	Co. Lat.	39.22.36,85
Log. sin. 1 co. ar. - -	5.3168000		
		Latitude of Shanklin Farm	50.37.23,15
Const Log. -	3.7634825		
Log. 2379 (+4) -	7.3763944		
Correct. +13″,80 Log.	1.1398769		

SHANKLIN FARM, May 14th, 1819. Barometer 30,08 inches, thermometer 50°,0. Chronometer too fast 4m.43s. Pole star on the northern meridian by the chronometer 9h.33m.35s.

Chronometer.	Level.		Time from the meridian.	N. v. Sines.
h. m. s.			h. m.	
9.10.30	+ 20	— 16	23.05	5068
9.13.18	+ 19	— 18	20.17	3914
9.18. 0	+ 11	— 26	15.35	2311
9.26.45	+ 17	— 19	6.50	0444
9.44. 6	+ 24	— 10	10.31	1053
9.46.10	+ 13	— 22	12.35	1507
9.48.15	+ 25	— 10	14.40	2047
9.51. 6	+ 15	— 20	17.31	2919
	+144	—141		2408

$\frac{(+144-141)}{2} \times 2'',4 = +3'',6$ cor for the level.

Const. Log.	- -	3.7634825
Log. 2408 (+4)	-	7.3816565
Correct. + 13″,97 Log	-	1.1451390

Readings, &c.

		° ′ ″
1st Vernier	-	328. 8.15
Second	- -	8. 2
Third	- -	8. 2
Fourth	- -	7.55
Mean	- -	328. 8. 3,5
Level	- +	3,6
Index	- +	13,0
	8)	328. 8.20,1
Observed Z. D.	-	41. 1. 2,51
Refract.	- +	50,92
Correct.	- - +	13,97
2 r′C.	- +	0,08
True Z. D.	-	41. 2. 7,48
App. P. D.	- —	1.39.31,32
Co. Lat.	-	39.22.36,16
Latitude of Shanklin Farm		50.37.23,84

Shanklin Farm, May 15th, 1819. Barometer 30,02 inches, thermometer 43°,5. Chronometer too fast $4^{m}.41^{s}$. Pole star on the northern meridian by the chronometer $9^{h}.29^{m}.38^{s}$.

Chronometer.	Level.		Time from the meridian.	N. v. Sines.	Readings, &c.	
h. m. s.			m. s.			° ′ ″
9. 6. 3	+ 24	— 28	23.35	5215	1st. Vernier - -	296.17.43
9.10. 3	+ 24	— 28	19.35	3648	Second - -	30
9.13.50	+ 22	— 30	15.48	2375	Third - -	40
9.16.52	+ 26	— 27	12.46	1551	Fourth - -	35
9.20.33	+ 27	— 23	9. 5	0785		
9.24.35	+ 24	— 27	5. 3	0243	Mean - -	296.17.37
9.27.54	+ 25	— 25	1.44	0029		+ 360. 0. 0
9.30.25	+ 23	— 27	0.47	0006	Level - -	— 44,40
9.33.18	+ 24	— 26	3.40	0128	Index - -	+ 13,0
9.36.17	+ 23	— 27	6.39	0421		
9.39. 5	+ 25	— 25	9.27	0850		16)656.17. 5,60
9.42.16	+ 24	— 26	12.38	1519		
9.44.32	+ 23	— 27	14.54	2113	Observed Z. D. -	41. 1. 4,10
9.47.30	+ 25	— 25	17.52	3037	Refract. -	+ 51,54
9.50.33	+ 21	— 28	20.55	4162	Correct. - -	+ 11,50
9.54. 0	+ 26	— 24	24.22	5647	2 r′C. -	+ 0,06
	+ 386	— 423		1983	True Z. D. -	41. 2. 7,20
					App. P. D. —	1.39.31,51

$\frac{(+386-423)}{2} \times 2'',4 = -44'',4$ cor. for the level

Const. Log. - -	3.7634825	Co. Lat. -	39.22.35,69
Log. 1983 (+4) - -	7.2973227	Latitude of Shanklin Farm	50.37.24,31
Correct. + 11″,50 Log. -	1.0608052.		

The mean of the three preceding results is 50°.37′.23″,77, and the greatest difference 1″,16. If to this mean 0″,17 be added we have 50°.37′.23″,94 for the latitude of the pendulum.

I had now to connect my station with that of Dunnose; a work attended with some difficulty, as Shanklin farm could not be seen from it, and the nature of the ground was very

unfavourable to the measurement of a base. The signal post however was visible from the farm, and I selected the most level part of the hill I could find, on which, with the assistance of Mr. FRANKS, I measured a line of 1140 feet. The angles were taken with the greatest care, and are given with the other necessary data in the Appendix, from which the distance from Dunnose to the chimney of the summer house appears to be 3901 feet, and its bearing 60° 58′ 11″ to the north east; whence the distance on the meridian is 1893 feet, or 18″,67. The distance from the signal post was also calculated, and found to differ only one foot from that of the station.

Fearing from the nature of the ground on which the base was measured, that this determination might be erroneous, I was anxious to verify it by some other method. For this purpose I chose a spot on the side of the hill, which was very level, on which I measured with great care a distance of 100 yards. The direction of this base was perpendicular to a line joining the summer house and the signal post, in which line was also its commencement. I then measured the distance from the signal post to the commencement of the base. By means of eight repetitions with the Repeating Circle, the angle subtended by this base, at a spot 22 feet from the chimney of the summer house towards the signal post, was determined with great precision; and having also the angle of elevation, the horizontal distance from the commencement of the base was obtained, to which 22 feet being added, and also the measured distance from the base to the Signal Post, the result was 3896 feet, for the distance from the Signal Post, to the chimney of the summer house, differing only four feet from the former determination.

If from 50°.37′.23″,94 (the latitude of the summer house) 18″,67 be subtracted, we have 50°.37′.5″,27 for the latitude of Dunnose by the Repeating Circle.

The latitude of Dunnose is stated in the " Account of the Trigonometrical Survey," to be 50°.37′.8″,6, on the supposition of that of Greenwich being 51°.28′.40″. But this latitude, as before stated, is found from the more recent observations of the present Astronomer Royal, to be 1″,99 in excess, if the French refractions be employed; therefore 50°.37′.6″,61 is the latitude of Dunnose by the Trigonometrical Survey, differing 1″,34 in excess from the result obtained by the Repeating Circle.

I may here remark, that the latitude of Dunnose deduced from the observations made with the Repeating Circle, differs only 0″,05 from the latitude of that station given in the first volume of the account of the survey, and which appears to have been derived trigonometrically from the latitude of Greenwich.

Results of the preceding Operations.

It now remains to give in one view, the results of the operations that have been detailed. These are comprised in the following table. It would have been desirable to have expressed the length of the pendulum vibrating seconds, in parts of the scale which forms the basis of the Trigonometrical Survey of Great Britain, the Commissioners of Weights and Measures having agreed to recommend, that "the standard "used in the Trigonometrical Survey of Great Britain should "be considered as affording the most authentic determination "of the linear measure of the United Kingdom." But as experiments are yet wanting to enable me to do this with sufficient accuracy, I have given the length of the pendulum in parts of Sir George Shuckburgh's standard scale, the correction for the difference between which, and the national standard of linear measure, may be readily applied hereafter.

The length of the pendulum vibrating seconds in the latitude of London, is stated in the Phil. Trans. for 1818, *to be* 39,13860 *inches. But I have here to notice a very important omission, which I am obliged to Mr.* Troughton *for having pointed out in the first number of the Edinburgh Philosophical Journal. It may be seen that in computing the specific gravity of the pendulum, I have neglected to include the deal ends.* Anxious to supply this omission in the most unexceptionable manner, I thought it best to take the specific gravity of the whole pendulum, and for this purpose requested Mr. Barton, Comptroller of his Majesty's Mint, to allow me the use of the fine balance lately constructed under his directions, a request with which he

most obligingly complied, and favoured me with his assistance, and with every requisite for making the experiment.

A deal trough was prepared seven feet long, nine inches wide, and the same depth. The pendulum was slung horizontally from the scale pan, by a fine iron wire. The weight of the whole was carefully determined in air, and found to be 66904 grains. The trough which had been previously placed beneath the pendulum, was then filled with distilled water, and the weight of water displaced was found to be 9066 grains. The small portion of iron wire which was immersed in the water was carefully noted; the weight of the wire by which the pendulum was suspended was 56 grains, and the weight of water equal in bulk to that part of the wire which was immersed was 2,5 grains. The temperature of the water was 68°, and that of the atmosphere 62°; the barometer 29,9 inches. Hence we have the weight of the pendulum 66858,8 grains in vacuo, at the temperature of 62°; the weight of an equal bulk of water at the same temperature, 9068,4 grains; and the resulting specific gravity of the pendulum, 7,3727.

Employing this specific gravity in computing the allowance for the mean buoyancy of the atmosphere, we obtain ,00624 *for this correction instead of* ,00545, *the former erroneous conclusion. Besides this, the allowance* + ,00031 *for the height of the pendulum above the level of the sea, should, according to Dr.* YOUNG'S *investigation, have been multiplied by* $\frac{66}{100}$, *making* + ,00021 *of an inch. These corrections being applied, we have* 39,13929 *inches of Sir* G. SHUCKBURGH'S *standard scale, for the length of the pendulum vibrating seconds in the latitude of London.*

Wishing to compare with this, the result which would have been obtained by means of the weights and specific gravities of the different parts of the pendulum, I carefully measured

the deal ends, and found them to contain 3,956 cubic inches. The weight of the knife edges was 370 grains, and their specific gravity 7,84.

With these data, and taking the specific gravity of deal at 0,49; the specific gravity of the whole pendulum will be found to vary from the more accurate determination above given, a quantity which would have occasioned a difference in the length of the seconds pendulum of only $\frac{1}{50000}$ of an inch.

Place of observation.	Latitude.	Vibrations in a mean solar day.	Length of the Pendulum vibrating seconds in parts of Sir George Shuckburgh's scale.
	° ′ ″		Inches.
Unst - -	60.45.28,01	86096,90	39,17146
Portsoy - -	57.40,58,65	86086,05	39,16159
Leith Fort -	55.58.40,80	86079,40	39,15554
Clifton -	53.27.43,12	86068,90	39,14600
Arbury Hill	52.12.55,32	86065,05	39,14250
London -	51.31. 8,40	86061,52	39,13929
Shanklin Farm	50.37.23,94	86058,07	39,13614

Of the Figure of the Earth.

The deviation of the figure of the earth from a perfect sphere, is expressed by a fraction, having for its numerator the difference between the equatorial and polar diameters, and for its denominator the diameter at the equator; this is termed the *compression* or *ellipticity*.

If the earth were a perfect sphere, composed of homogeneous materials, as a fluid, and at rest, gravity at every point in its surface would be the same. But if this sphere were made to revolve about an axis, its particles would endeavour to fly off with a centrifugal force proportionate to the distance from the axis of rotation; the equatorial parts would become elevated, those at the pole and its vicinity depressed, and the sphere would assume the form of a spheroid, the centrifugal force thus generated acting in opposition to gravity, and diminishing it more and more from the Pole, where the centrifugal force is nothing, to the Equator where it is a maximum.

But besides this diminution of gravity from centrifugal force, in proceeding from the pole to the equator, a farther reduction takes place in consequence of the elliptical form which the earth has now assumed. For the parts about the Pole being nearer to the centre of the spheroid than those at the Equator, will be more strongly attracted, and this farther reduction of gravity, whatever it may be, varies with the figure of the earth, and as we shall presently see, with a variation in the density of the strata of which it is composed.

If we conceive two fluid columns meeting in the centre of such a spheroid, the one proceeding from the Pole and the

other from the Equator, it follows in order that the spheroid may preserve a state of equilibrium, that the pressure of the equatorial and polar columns on the centre must be equal. The equatorial column then has been lengthened in proportion to the diminution of its gravity. The ellipticity therefore, and the diminution of gravity from the Pole to the Equator, will, on this supposition of a homogenous spheroid, be expressed by the same fraction, which NEWTON has demonstrated to be $\frac{1}{230}$.

If now we suppose new matter to be added to the centre of such homogeneous spheroid, or its density there to be increased, this matter, by its additional attraction, will cause a greater increase of gravitation at the Pole than at the Equator, in consequence of the distance from the Pole to the centre being the less; but the equatorial column being the longer, and therefore consisting of a greater quantity of matter, its gravity or pressure on the centre will be more increased by this new attraction than that of the polar column; and in order to restore the equilibrium thus destroyed, the polar column must become longer, and the equatorial column shorter than before. Thus the ellipticity of the spheroid will be diminished, but the difference of gravitation at the Pole and at the Equator will, at the same time, be increased.

HUYGENS considered the whole attractive force to reside in the centre, or the earth to be infinitely dense there, and on this supposition, computing its ellipticity, he found it to be $\frac{1}{578}$.

But experiments with the pendulum soon sufficiently proved that the earth was neither homogeneous, nor, it is scarcely necessary to say, infinitely dense at its centre; but that it

probably increased in density from the surface to the centre, the ellipticity being consequently somewhere between $\frac{1}{578}$ and $\frac{1}{230}$.

As it appears then that the ellipticity of the earth varies with any difference in the diminution of gravitation from the Pole to the Equator, and that this last depends in its turn on the ellipticity; it might have been supposed that any attempt to arrive at the figure of the earth in this way must have been hopeless.

But it was reserved for CLAIRAUT to remove this difficulty. He found that however the density of the earth be supposed to vary, the fraction expressing its ellipticity increases as the fraction expressing the diminution of gravity from the pole to the equator diminishes, and vice versa; and in his admirable work on the figure of the earth, he has demonstrated this beautiful and important theorem; that *the sum of the two fractions expressing the ellipticity and the diminution of gravity from the Pole to the Equator, is always a constant quantity, and equal to* $\frac{5}{2}$ *of the fraction expressing the ratio of centrifugal force to that of gravity at the equator.*

If then the decrease of gravity from the Pole to the Equator can be discovered, and it be subtracted from this constant quantity, the remainder will be the fraction expressing the ellipticity of the spheroid.

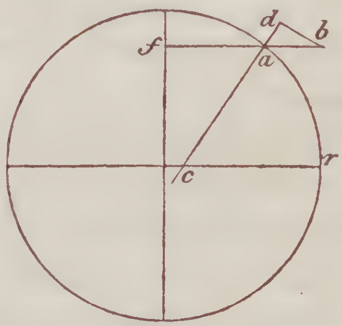
The diminution of gravity may be known by finding the difference of the lengths of the two pendulums vibrating in equal times at the Pole and at the Equator, as it may be easily demonstrated that the lengths of such pendulums are to each other directly as gravitation; or, if an invariable pendulum, such as I have used, be employed, the squares of the observed

number of vibrations in 24 hours, in different latitudes, will be to each other as gravitation in such latitudes.

But as experiments on the pendulum cannot be made at the Pole, it remains to describe the manner in which the diminution of gravity from the Pole to the Equator, may be obtained by observations made at intermediate stations.

I have remarked, that the centrifugal force varies as the distance from the axis of rotation; that is as the cosine of the latitude; thus at the Equator it is the greatest, at the Poles it is nothing.

But the whole of the centrifugal force does not act in opposition to gravity except at the Equator; for let *cd* be the direction of gravity, *fb* that of centrifugal force, and let the centrifugal force for the latitude *a*, be expressed by the line *ab*; if this be resolved into two forces *ad* and *db*, that portion which acts in opposition to gravity will be expressed by *ad*. But if *ab* be made the radius, *ad* is the cosine of the angle *dab*, = *acr*, the latitude of the point *a*. The effect then of the centrifugal force at *a*, in counteracting gravity, is still farther diminished in the proportion of the cosine of the latitude to the radius; whence it follows, that the diminution of gravity from this cause, in proceeding from the Pole to the Equator, will be as the difference of the squares of the cosines of the latitudes.



From the expression for the force of gravity at the surface of a spheroid,* we may readily perceive that that part of the

* $f = \frac{4\pi b}{3}\left(1 + \frac{c}{b}\cdot\frac{4 - \sin^2\varphi}{5}\right)$ in which the $\sin^2\varphi$ is the only variable quantity, φ being the angle of the terrestrial radius with the Equator.

diminution which depends on the elliptical form of the earth, follows very nearly the same law; therefore the increase of gravitation in proceeding from the Equator to the Pole, may be taken as the increase of the square of the sine of the latitude; * and this will also express the corresponding variation in the length of the pendulum.

Let E = The length of the pendulum vibrating seconds at the Equator.

d = The difference between the length at the Equator and at the Pole.

m = The length of the pendulum in the latitude L.

n = The length of the pendulum in the latitude L′.

Then from what has been stated,

$$m = E + d \,.\, \sin^2 L$$

$$n = E + d \,.\, \sin^2 L'$$

$$m - n = (E + d \sin^2 L) - (E + d \sin^2 L') = d (\sin^2 L - \sin^2 L')$$

Hence $d = \dfrac{m-n}{\sin(L+L') \times \sin(L-L')}$

and $E = m - (d \sin^2 L.)$

Therefore $\frac{d}{E}$ expresses the diminution of gravity from the Pole to the Equator, which being subtracted from $\frac{5}{2}$ of the proportion of centrifugal force to gravity at the Equator, will give the ellipticity of the spheroid.

The centrifugal force at the Equator is expressed by the deflection of a point on its surface from the tangent, in one second of mean solar time. This is equal to the versed sine of 15″,0418, the arc which the earth describes in its diurnal revolution in one second; and taking the radius of the Equator at 3967,5 miles, is found to be ,055696 of a foot.

* The sin² + the cosine ² is a constant quantity, equal to the radius², consequently as the cosine ² diminishes, the sine² must increase, and vice versa.

If g, be the space a body falls through in one second of time at the Equator, L the length of the seconds pendulum, and c the circumference of a circle, the diameter being 1,

$$g = \tfrac{1}{2} \mathrm{L} \times c^2.$$

The length of the pendulum vibrating seconds at the equator, deduced from the observations at Unst and Dunnose, by the preceding formula, appears to be 39,00734 inches, and g, or gravitation at the Equator, to be equal to 16,0412 feet. Hence the centrifugal force at the equator is $\frac{1}{288,013}$ of gravitation, or $\frac{1}{289,014}$ of gravity; which last being multiplied by $\frac{5}{2}$, we have ,0086501 for the sum of the fractions expressing the ellipticity of the earth and the diminution of gravity, from the Pole to the Equator.

In the following Table are given the diminution of gravity from the Pole to the Equator, and the resulting compression, deduced in the manner which has been described, by comparing the observations at each station, successively with those at all the others.

	Diminution of gravity from the Pole to the Equator.	Compression.
Unst and Portsoy - -	,0053639	$\frac{1}{304,3}$
Leith Fort - -	,0054840	$\frac{1}{315,8}$
Clifton - -	,0056340	$\frac{1}{331,5}$
Arbury Hill -	,0054282	$\frac{1}{310,3}$
London - -	,0055510	$\frac{1}{322,7}$
Dunnose - -	,0055262	$\frac{1}{320,1}$
Portsoy and Leith Fort -	,0056920	$\frac{1}{338,0}$
Clifton - -	,0058194	$\frac{1}{353,2}$
Arbury Hill -	,0054620	$\frac{1}{313,7}$
London - -	,0056382	$\frac{1}{332,0}$
Dunnose - -	,0055920	$\frac{1}{326,9}$
Leith Fort and Clifton -	,0059033	$\frac{1}{364,0}$
Arbury Hill -	,0053615	$\frac{1}{304,1}$
London - -	,0056186	$\frac{1}{329,8}$
Dunnose -	,0055614	$\frac{1}{323,7}$
Clifton and Arbury Hill -	,0042956	$\frac{1}{229,6}$
London -	,0052590	$\frac{1}{294,9}$
Dunnose -	,0052616	$\frac{1}{295,1}$
Arbury Hill and London -	,0069767	$\frac{1}{597,5}$
Dunnose -	,0060212	$\frac{1}{380,3}$
London and Dunnose -	,0052837	$\frac{1}{297,0}$

From the experiments given in the former part of this

Report, it appears probable, that if the uncertainty which must exist in the allowance for the height above the level of the sea be excepted, the error in the number of vibrations of the pendulum at any particular station, does not amount to so much as one tenth of a vibration, which is nearly equivalent to $\frac{1}{400000}$ part of the length of the seconds pendulum. To this degree of accuracy consequently may gravitation be determined by the apparatus I have employed; and in passing through a country composed of materials of various densities, the pendulum may be expected to indicate such variation with very considerable precision.

The diminution of gravity from the Pole to the Equator is derived from the decrease which is observed to take place between any two given latitudes; consequently if no irregular attraction occurred, the results, computed from different portions of the meridian, should be the same. But it may be seen in the preceding table, that the number expressing the diminution of gravity, from the observations at Unst and Portsoy, is less than that deduced from the arc between Unst and Leith, and that this number goes on increasing to Clifton, diminishes at Arbury Hill, and increases again at London. It may also be remarked, that the diminution of gravity, derived from Unst and Dunnose, is less than that deduced from Portsoy and Dunnose; from all which it seems probable that in advancing southward, gravity decreases more than it ought to do from theory; that there exists an assemblage of materials of greater density than common in the vicinity of Portsoy, and that the density of the strata to the southward becomes less and less until we arrive at Clifton, where it seems to be considerably in defect.

At Arbury Hill, a sudden increase of gravitation is percep-

tible, and at the short distance of London, this additional force is no longer sensible. From its intensity, and the limited sphere of its action, it might perhaps be inferred that the disturbing material is of considerable density, and not very distant from the surface.

It must be evident that nothing very decisive respecting the general ellipticity of the Meridian can be deduced from the present experiments. For this purpose it is requisite that the extreme stations should comprise an arc of sufficient length to render the effect of irregular attraction insensible; and this effect might be diminished, if not wholly prevented, by selecting stations of similar geological character, and which should differ as little as possible in elevation above the level of the sea.

If however some deduction be made for the superior density which it has been remarked exists at Portsoy, the compression $\frac{1}{304}$ deduced from that station and Unst, may perhaps be considered as not far distant from the truth, both being situated on rocks of a similar nature; Unst consisting chiefly of serpentine, and Portsoy, of serpentine, slate, and granite; and as $\frac{1}{310}$ the ellipticity given by the experiments at Unst and Arbury Hill, is nearly the same as that resulting from Unst and Portsoy, it would be no improbable conjecture that the sudden increase of gravitation observed at Arbury Hill, may be occasioned by a rock of primitive formation, approaching the surface of the earth in the vicinity of that station.*

These facts appear sufficient to explain the anomalies which

* Since the above was written, I find the conjecture I have hazarded remarkably supported by fact; for on consulting SMITH's Geological Map of England, it appears that Mount Sorrel, a mass of granite, is situated, together with other rocks of primitive formation, about 30 miles to the north of Arbury Hill.

have been remarked in the Trigonometrical Survey of Great Britain. For if the disturbing force in the neighbourhood of Arbury Hill, were supposed to be situated to the north of that station, the plumb line would be attracted northward, the observed latitude would be less than the true, and the length of the degree deduced from the arc between Dunnose and Arbury would be in excess, and that derived from the arc between Clifton and Arbury in defect. This last error will be augmented, if we suppose the attraction of the matter near Arbury Hill to be felt at Clifton, and the plumb line at that station to be drawn towards the south.

M. BIOT, by a comparison of his numerous experiments at Unst with those made at Formentara and Dunkirk, in conjunction with M. ARAGO, obtains $\frac{1}{310}$ for the resulting compression. But if the allowance for the elevation of Formentara above the level of the sea, be corrected in the manner suggested by Dr. YOUNG, the ellipticity should be about $\frac{1}{319}$. The details of M. BIOT's experiments have not yet been published, but it affords me much gratification to learn, that the acceleration of the pendulum between London and Unst, computed by M. BIOT, from his observations at Unst and those at Formentara, using $\frac{1}{310}$ for the compression, differs only 0",6 from the result of my experiments; a difference which may probably be referred to the superior density of Unst, compared with that of the substrata of London.

London, June, 1819.

APPENDIX.

CONTAINING THE OBSERVATIONS FROM WHICH THE PRECEDING RESULTS WERE COMPUTED.

Observations for determining the rate of the clock.

WITH respect to the following Table of Transits it may be necessary to remark that the results in the column headed "Mean Chronometer," were obtained by taking the mean of the 1st and 5th wires, of the 2d and 4th, and again taking the mean of these means and the third wire, instead of taking the mean of the five wires, which is the usual method. This was done for the sake of comparing the result of each pair of wires with that of the meridian wire.

Transits observed at UNST.

Date.	Stars.	1	2	Merid. wire. 3	4	5	Mean Chronometer.	Clock.
1818.		h. m. s.	m. s.	m. s.	m. s.	m. s.	h. m. s.	h. m .s
July 22	Arcturus	6. 8.14,0	8.36,5	8.59,0	9.21,5	9.44,0	6. 8.59	6.14.18,14
	γ Ophiuchi	9. ——	—	50. 9,5	—	—	9.50. 9,5	9.55.36,41
	η Serpentis	10.12.15,0	12.36,0	12.57,0	13.18,5	13.39,5	10.12.57,17	10.18.25,08
	α Lyræ	10.30.42,5	31. 9,5	31.36,5	32. 4,0	32.30,5	10.31.36,58	10.37. 5
	α Orionis	21.43.41	44. 2,5	44.23,5	44.45,0	45. 6,5	21.44.23,67	21.50.15,3
24	☉'s centre	0. 6.27	6.49,5	7.12,25	7.35	7.57	0. 7.12,17	0.13.59,32
25	α Ophiuchi	9.15. 2,5	15.24	15.45,5	16. 7,5	16.29	9.15.45,62	9.23.43,56
	γ Ophiuchi	9. ——	37.57,5	38.19	38.40,5	—	9.38.19	9.46.18,11
	η Serpentis	10. 0.23,5	0.45,5	1. 6,5	1.27,5	1.49	10. 1. 6,41	10. 9. 6,1
	α Lyræ	10.18.50,5	19.17,5	19.44	20.12	20.38,5	10.19.44,41	10.27.44,82
26	☉'s centre.	0. 6.24,5	6.46,75	7. 9,25	7.31,75	7.54,5	0. 7. 9,33	0.15.41,63

Oil was applied to the scapement without stopping the clock.

Date.	Stars.	1.	2.	Merid. wire. 3.	4.	5.	Mean Chronometer.	Clock.
		h. m. s.	m. s.	m. s.	m. s.	m s.	h. m. s.	h. m. s.
July. 27	α Orionis	21.23.55,5	—	—	—	—	21.24.38,17	21.34.48,69
28	☉'s centre	0. 6.23,75	6.46,25	7. 8,5	7.31	7.53,5	0. 7. 8,58	0.17.25,41
	Arcturus	5.44.31	44.53	45.15,5	—	—	5.45.15,66	5.55.45,27
	α Ophiuchi	9. 3.10	3.32	3.53,5	4.15,5	4.37	9. 3.53,58	9.14.30,51
	ν Ophiuchi	9.25.43,5	26. 5	26.26,5	26.48,5	27. 9,5	9.26.26,58	9.37. 4,48
	η Serpentis	9.48.32	48.53,5	49.14	49.35,5	49.57,0	9.49.14,03	9.59.52,73
	α Lyræ	10. 6.58,5	7.25,5	7.52,5	8.20	8.47	10. 7.52,67	10.18.32,11
	Transits observed at PORTSOY—1st. Series.							
Aug. 5.	ν Ophiuchi	9. 0.51	1.12,5	1.34	1.56	2.17	9. 1.34,06	9. 2.35,99
	η Serpentis	9. —	24. 2	24.23,5	24.44,5	25. 5,5	9.24.23,30	9.25.25,99
	α Lyræ	9.42.19,5	42.46	43.13	43.40,5	44. 7,5	9.43.13,27	9.44.16,20
	b	10.14.42,5	15. 4,5	15.26	15.48	16. 9,5	10.15.26,08	10.16.29,86
	μ Aquilæ	10.36.46,5	37. 8	37.29	37.51	38.12	10.37.29,25	10.38.33,58
	α Aquilæ	10.53.26	—	54. 9	54.30,5	54.51,5	10.54. 8,88	10.55.13,62
6	☉'s centre	0.12 35,25	12.57,5	13.19,75	13.41,75	14. 4	0.13.19,66	0.14.41,62
	α Ophiuchi	8.34.25,5	34.47,5	35. 9,0	35.30,5	35.52	8.35. 8,92	8.36.42,60
7	☉'s centre	0.12.28	12.50,25	13.12,25	13.34,5	13.56,5	0.13.12,29	0.15. 7,95
8	☉'s centre	0.12.19,75	12.41,75	13. 3,50	13.26	13.47,5	0.13. 3,66	0.15.36,56
	Arcturus	5. 7.54	8.16,5	8.39	9. 2	9.24,5	5. 8.39,17	5.11.20,51
	α Ophiuchi	8.26.31,5	26.53	27.14,5	27.37	27.58	8.27.14,56	8.30. 1,45
	ν Ophiuchi	8.48.59,5	49.21	49.42	50. 4	50.25	8.49.42.25	8.52.29,70
	η Serpentis	9.11.49	12.10,5	12.31,5	12.53	13.14,5	9.12.31,66	9.15.19,73
	α Lyræ	9.30.27,5	30.54	31.21,5	31.49	32.16	9.31.21,58	9.34.10,19
	α Aquilæ	10.41.35	41.56	42.17,5	42.39	43. 0,5	10.42.17,58	10.45. 8,14
10	☉'s centre	0.12. 2,25	12.23,75	12.45,75	13. 8,25	13.29,75	0.12.45,92	0.16.38,83
	Arcturns	5. 0. 0	0.22,5	0.45	1. 7,5	1.30	5. 0.45	5. 4.46,51
	α Ophiuchi	8.18.38	18 59,5	19.21	19.43	20. 4,5	8.19.21,16	8.23.28,67
	ν Ophiuchi	8.41. 6	41.27	41.48,5	42.10,5	42.31,5	8.41.48,66	8.45.56,85
	η Serpentis	9. 3.55,5	4.16,5	4.37,5	4.59,5	5.20,5	9. 4.37,83	9. 8.46,76
	α Lyræ	9.22.34	23. 1	23.27,5	23.55,5	24.22	9.23.27,92	9.27.37,34
	a	9.48.30	48.51,5	49.12	49.34	49.55	9.49.12,42	9.53.22,62
	b	9.54.57,5	55.19	55.40,5	56. 3	56.24,5	9.55.40,83	9.59.51,24
	α Aquilæ	10.33.41	34. 2	34.23,5	34.45,5	35. 6,5	10.34.23,66	10.38.35,49
11	α Ophiuchi	8.14.39	15. 0,5	15.22	15.44	16. 5,5	8.15.22,17	8.20.13,59
	ν Ophiuchi	8.37. 7	37.28,5	37.49,5	38.11,5	38.32,5	8.37.49,75	8.42.41,94
	η Serpentis	8.59.57	60.18	0.39	1. 0,5	1.21,5	9. 0.39,17	9. 5.32,03
	α Lyræ	9.18.35,5	19. 2	19.29	19.56,5	20.23,5	9.19.29,10	9.24.22,52
	a	9.44.31	44.52,5	45.13,5	45.35	45.56	9.45.13,58	9.50. 7,82
	b	9.50.58,5	51.20,5	51.42	52. 4	52.25,5	9.51.42,08	9.56.36,52
	μ Aquilæ	10.13. 3	13.24	13.45	14. 7	14.28	10.13.45,33	10.18.40,52
	α Aquilæ	10.29.42	30. 3,5	30.25	30.46,5	31. 7,5	10.30.24,92	10.35.20,47

Date.	Stars.	1.	2.	Merid. wire. 3.	4.	5.	Mean Chronometer.	Clock.
		h. m. s.	m. s.	m. s.	m. s.	m. s.	h. m. s.	h. m. s.
Aug. 12	☉'s centre	0.11.38,5	12. 0	12.22	12.44,25	13. 6	0.12.22,12	0.17.42,63
	Arcturus	4.52. 3	52.25,5	52.48	53.10,5	53.33	4.52.48	4.58.16,63
	α Ophiuchi	8.10.40,5	11. 2	11.24	11.45,5	12. 7	8.11.23,83	8.16.58,52
	ν Ophiuchi	8.33. 8,5	33.30	33.51,5	34.13	34.34,5	8.33.51,5	8.39.26,94
	η Serpentis	8.55.58,5	56.19,5	56.40,5	57. 2	57.23	8.56.40,67	9. 2.17,04
	α Lyræ	9.14.36,5	15. 3,5	15.30,5	15.58	16.24,5	9.15.30,58	9.21. 7,43
	a	9.40.33	40.54	41.15	41.36,5	41.57,5	9.41.15,17	9.46.52,91
	b	9.47. 0,5	47.22	47.43,5	48. 5,5	48.27	9.47.43,67	9.53.21,61
	μ Aquilæ	10. 9. 4	9.25	9.46,5	10. 8,5	10.29,5	10. 9.46,67	10.15.25,11
	α Aquilæ	10.25.43,5	26. 5	26.26	26.48	27. 9	10.26.26,25	10.32. 5,33
Transits observed at PORTSOY—2d Series.								
Aug. 13	☉'s centre	0.11.17	11.48,75	12.10,5	12.32,5	12.54,5	0.12.10,62	0.11.47,72
	Arcturus	4.48. 5	48.27,5	48.50	49.12,5	49.35	4.48.50	4.48.35,44
	α Ophiuchi	8. 6.42,5	7. 4	7.25,5	7.47,5	8. 9	8. 7.25,67	8. 7.17,18
14	α Ophiuchi	8. 2.45	3. 6,5	3.28	3.50	4.11,5	8. 3.28,17	8. 4. 2,83
	ν Ophiuchi	8.25.13,5	25.34,5	25.56	26.17,5	26.39	8.25.56,08	8.26.31,46
	η Serpentis	8.48. 3,5	48.24	48.45	49. 6,5	49.27,5	8.48.45,25	8.49.21,19
	α Lyræ	9. 6.41	7. 8	7.35	8. 2,5	8.29,5	9. 7.35,17	9. 8.11,68
	μ Aquilæ	10. 1. 9	1.30	1.51,5	2.13	2.34	10. 1.51,5	10. 2.29,88
	α Aquilæ	10.17.48	18. 9,5	18.31	18.52,5	19.13,5	10.18.30,92	10.19. 9,84
15	☉'s centre	0.11. 0,5	11.22,25	11.44	12. 6,25	12.27,75	0.11.44,12	0.12.49,27
	Arcturus	4.40. 9	40.31	40.53,5	41.16	41.39	4.40.53,5	4.42. 6,66
	α Ophiuchi	7.58.46,5	59. 8	59.29,5	59.51,5	60.13	7.59.29,67	8. 0.48,78
	ν Ophiuchi	8.21.14	21.35,5	21.57	22.18,5	22.40	8.21 57	8.23.16,94
	η Serpentis	8.44. 4,5	44.25	44.46	45. 7,5	45.29	8.44.46,33	8.46. 7
	α Lyræ	9. 2. 42	3. 9	3.36	4. 3,5	4.30,5	9. 3.36,17	9. 4.57,59
16	☉'s centre	0.10.47,75	11. 9,25	11.31	11.53	12.14,5	0.11.31,08	0.13.19,72
	Arcturus	4.36.11,5	36.33,5	36.56	37.19	37.41	4.36.56,17	4.38.53,17
	α Ophiuchi	7.54.48,5	55.10	55.31,7	55.53,7	56.15	7.55.31,73	7.57.34,88
	η Serpentis	8.40. 6,5	—	40.48,7	41.10	—	8.40.48,67	8.42.53,09
	α Lyræ	8.58.44,7	59.11,8	59.38,5	60. 6	60.32,9	8.59.38,73	9. 1.43,81
17	☉'s centre	0.10.33,55	10.55,25	11.16,75	11.38,65	12. 0,45	0.11.16,9	0.13.49,88
	α Ophiuchi	7.50.50,7	51.12,3	51.34	51.56	52.17,3	7.51.34	7.54.21,23
	ν Ophiuchi	8.13.19	13.40,1	14. 1,5	14.23,2	14.44,5	8.14. 1,61	8.16.49,55
	η Serpentis	8.36. 9	36.29,9	36.51	37.12,3	37.33,3	8.36.51,08	8.39.39,77
	α Lyræ	8.54.46,6	55.13,7	55.40,7	56. 8	56.35	8.55.40,77	8.58.30,19
	μ Aquilæ	9.49.14,7	49.35,8	49.57	50.18,7	50.39,8	9.49.57,17	9.52.48,21
	α Aquilæ	10. 5.54	6.15,3	6.36,6	6.58,2	7.19,3	10. 6.36,67	10. 9.28,18
18	Arcturus	4.28.16,7	28.39,3	—	—	29.46,7	4.29. 1,70	4.32.25,84
	ν Ophiuchi	8. ——	9.43,7	—	10.26,8	10.48	8.10. 5,18	8.13.36,30
	η Serpentis	8.32.12	32.33,3	32.54,3	—	33.36,8	8.32.54,42	8.36.26,36
	α Lyræ	8. ——	—	51.44	52.11,3	52.38	8.51.43,95	8.55.16,39

Date.	Stars.	1.	2.	Merid. wire. 3.	4.	5.	Mean Chronometer.	Clock.
		h. m. s.	m. s.	m. s.	m. s.	m. s.	h. m. s.	h. m. s.
Aug. 19	☉'s 1st limb	0. 9. 0,7	9.22,2	—	10. 6,0	—	0.10.49,15	0.14.49,28
	☉'s 2d limb	—	11.32,5	11.54	—	12.37,5		
Transits observed at Leith Fort.—1st Series.								
31	ϰ Capricorni	9.49.25,1	49.47,5	50. 9,5	50.32	50.54,3	9.50. 9,65	9.49.41,04
	α Equulei	10.37.31,7	—	38.14	38.35	38.56,3	10.38.14	10.37.46,18
	β Aquarii	10.52.45	53. 6,2	53.27,3	53.49	54.10	10.53.27,47	10.52.59,93
	ι Pegasi -	11. 5.57	6.18,5	6.39,5	7. 1	7.22,7	11. 6.39,7	11. 6.12,53
	ο Aquarii	11.24.35,1	24.56	25.17	25.38,3	26. 0	11.25.17,25	11.24.50,38
	γ Aquarii -	11.42.53,4	43.14,2	43.35,3	43.56,5	44.18	11.43.35,45	11.43. 8,89
	ϰ Aquarii -	11. ——	59.16,7	59.37,8	59.59	—	11.59.37,85	11.59.11,46
Sept. 2	☉'s 1st limb	—	7.32,7	7.54	8.15,8	8.37	0. 8.58,43	0. 9.18,05
	☉'s 2d limb	0. 9.20	9.41,5	10. 2,5	10.24	10.45,5		
	α Capricorni	9.41.24,5	41.46,8	42. 9	42.31,4	42.53,7	9.42. 9,07	9.42.40,21
	ι Aquarii -	10. 0.42,4	1. 3,8	1.25,3	1.47	2. 8,4	10. 1.25,37	10. 1.56,92
	α Equulei -	10.29.30,9	29.51,9	30.13	—	—	10.30.13,1	10.30.45,31
	β Aquarii -	10.44.45	45. 5,5	45.27	45.48,3	46. 9,7	10.45.27,07	10.45.59,62
	ο Aquarii -	11.16.34,5	16.55,7	17.16,5	17.38	17.59	11.17.16,7	11.17.49,91
	η Aquarii -	11.53.57,1	54.18,3	54.39,5	55. 0,8	55.22	11.54.39,53	11.55.13,67
	ξ Pegasi -	12. 0. 6,8	0.28,3	0.49,8	1.11,5	1.33	12. 0.49,87	12. 1.24,05
4	α Capricorni	9. ——	—	34.12	34.34,3	34.56,6	9.34.11,98	9.35.42,16
	ε Aquarii -	9.52.45,5	53. 7	53.28,3	53.50	54.11,4	9.53.28,42	9.54.59,09
	α Equulei -	10.21.33,6	21.54,8	22.16	22.37	22.58,3	10.22.15,95	10.23.47,39
	β Aquarii -	10.36.47,3	37. 8,5	37.29,5	37.51	38.12,3	10.37.29,68	10.39. 1,37
	ε Pegasi -	10.49.59,2	50.20,5	50.41,8	51. 3,5	51.25	10.50.41,99	10.52.13,94
	ο Aquarii -	11. 8.37,1	8.58,3	9.19,4	9.40,8	10. 2	11. 9.19,5	11.10.51,95
	γ Aquarii -	11.26.55,6	27.16,5	27.37,5	27.59	28.19,9	11.27.37,67	11.29.10,60
	ϰ Aquarii -	11. ——	43.18,8	43.39,9	44. 1	44.22,3	11.43.39,9	11.45.13,07
	ξ Pegasi -	11. ——	52.31,7	52.52,5	53.14,5	53.36	11.52.52,82	11.54.26,26
5	☉'s 1st limb	—	—	6.47,8	7. 9,2	7.30,2	0. 7.51,93	0. 9.41,66
	☉'s 2d limb	0. 8.13,3	8.34,9	8.56,2	9.17,5	9.38,8		
6	☉'s 1st limb	0. 5.42,8	6. 4	6.25	6.46,4	7. 8	0. 7.29,35	0. 9.51,50
	☉'s 2d limb	0. 7.51	8.12	8.33,3	8.55	9.16		
Transits observed at Leith Fort.—2d Series.								
8	α Equulei -	10. 5.41	6. 2,4	6.23,4	6.45	7. 6	10. 6.23,53	10. 2.39,48
	β Aquarii -	10.20.55	21.16	21.37,4	21.59	22.20	10.21.37,47	10.17.53,83
	ε Pegasi -	10.34. 7	34.28,3	34.49,6	35.11	35.32,4	10.34.49,65	10.31. 6,30
	ο Aquarii -	10.52.45	53. 6	53.27	53.48,4	54. 9,6	10.53.27,17	10.49.44,22
	Pegasi -	11.17.25	17.46	18. 7,3	18.29	18.50	11.18. 7,43	11.14.25,06
	ϰ Aquarii -	11.27.5,5	27.26,5	27.47,6	28. 9,3	28.30,3	11.27.47,8	11.24. 5,68
	ζ Pegasi -	11.31. 6	31.27,3	31.48,5	32.10,3	32.31,5	11.31.48,68	11.28. 6,69
	ξ Pegasi -	11.36.17,5	36.39,1	37. 0,5	37.22	37.44	11.37. 0,6	11.33.18,73
	α Pegasi -	11.54.19,5	54.41,3	55. 3	55.25	55.46,6	11.55. 3,07	11.51.21,57

Date.	Stars.	Merid. wire 1.	2.	3.	4.	5.	Mean Chronometer.	Clock.
		h. m. s.	m. s.	m. s.	m. s.	m. s.	h. m. s.	h. m. s.
10	α Equulei -	9.57.45	58. 6	58.27	58.48,5	59. 9,4	9.58.27,15	9.55.54,46
	β Aquarii -	10.12.59	13.20	13.41	14. 2,5	14.23,7	10.13.41,2	10.11. 8,88
	ε Pegasi -	10.26.10,8	26.32	26.53,3	27.15	27.36,2	10.26.53,43	10.24.21,36
	Pegasi - -	11. 9.28,3	9.49,6	10.10,5	10.32	10.53,2	11.10.10,68	11. 7.39,80
	κ Aquarii -	11.19. 9	19.30	19.51,2	20.12,4	20.34	11.19.51,3	11.17.20,66
	ζ Pegasi -	11.23. 9,4	23.31	23.52	24.13,7	24.35,2	11.23.52,22	11.21.21,70
	ξ Pegasi -	11.28.21,3	28.42,5	29. 4	29.25,6	29.47,3	11.29. 4,12	11.26.33,72
	α Pegasi -	11.46.23	46.44,6	47. 6,3	47.28,3	47.50,3	11.47. 6,47	11.44.36,50
12	α Equulei -	9.49.47,4	50. 8,7	50.29,4	50.51	51.15,5	9.50.29,73	9.49.11,23
	β Aquarii -	10. 5. [illegible],3	5.22,5	5.43,5	6. 5	6.26,2	10. 5.43,67	10. 4.25,60
	ο Aquarii -	10.36.51,4	37.12,4	37.33,4	37.54,6	38.16	10.37.33,53	10.36.16,20
	Pegasi - -	11. 1.31,2	1.52,2	2.13,3	2.34,5	2.55,5	11. 2.13,33	11. 0.56,53
	κ Aquarii -	11.11.11,5	11.33	11.53,7	12.15,3	12.36,4	11.11.53,93	11.10.37,38
	ζ Pegasi -	11.15.12	15.33,4	15.54,5	16.16,4	16.37,5	11.15.54,72	11.14.38,28
	ξ Pegasi - -	11.20.23,6	20.45,1	21. 6,5	21.28,2	21.49,8	11.21. 6,65	11.19.50,34
	α Pegasi -	11.38.25,5	38.47,4	39. 9	39.31	39.53	11.39. 9,15	11.37.53,33
14	α Equulei -	9.41.54,6	42.15,7	42.37	42.58,3	43.19,4	9.42.37	9.42.28,05
	ε Pegasi -	10.10.20,2	10.41,5	11. 3	11.24,6	11.46,1	10.11. 3,07	10.10.54,92
	ο Aquarii -	10.28.58,4	29.19,4	29.40,5	30. 1,7	30.23	10.29.40,58	10.29.32,78
	Pegasi - -	10.53.38,2	53.59,2	54.20,3	54.41,8	55. 3	10.54.20,47	10.54.13,42
	κ Aquarii -	11. 3.18,6	3.40	4. 1	4.22,4	4.43,5	11. 4. 1,08	11. 3.54,32
	ζ Pegasi -	11. 7.19	7.40,3	8. 1,9	8.23,4	8.45	11. 8. 1,92	11. 7.55,24
	ξ Pegasi -	11.12.31	12.52,3	13.14	13.35,4	13.57	11.13.13,95	11.13. 7,40
	α Pegasi -	11.30.32,7	30.54,4	31.16,2	31.38,3	32. 0	11.31.16,3	11.31.10,33
				Transits observed at Clifton.				
Oct. 2	σ Aquilæ -	6.46. 8	46.29	46.50,1	47.11,3	47.32,7	6.46.50,2	6.46.47,45
	α Aquilæ -	6.57.47,4	58. 8,7	58.30	58.51,7	59.13	6.58.30,13	6.58.27,38
	θ Aquilæ -	7.17.44,4	18. 5,5	18.26,5	18.47,6	19. 8,8	7.18.26,55	7.18.23,75
	α Equulei -	8.22.23,4	22.44,4	23. 5,4	23.27	23.48	8.23. 5,6	8.23. 2,35
	ε Capricorni	8.42.24	42.47	43. 9,1	43.32	43.54,5	8.43. 9,28	8.43. 5,98
	α Aquarii -	9.11.57	12.18,1	12.39,4	13. 0,5	13.21,7	9.12.39,35	9.12.35,95
	γ Aquarii -	9.27.43,8	28. 5	28.25,7	28.47	29. 8,1	9.28.25,88	9.28.22,38
3	☉'s { 1st limb	11.47.29	—	—	—	48.53,7	} 11.49.15,8	11.49. 6,5
	☉'s { 2d limb	—	—	50.20	50.41,2	51. 2,7		
	σ Aquilæ -	6.42.10,3	42.31,4	42.52,7	43.14	43.35,3	6.42.52,73	6.42.40,48
	α Aquilæ -	6.53.50	54.11,4	54.32,4	54.54	55.15,5	6.54.32,62	6.54.20,37
	θ Aquilæ -	7.13.47	14. 8,1	14.29,1	14.50,5	15.11,7	7.14.29,25	7.14.16,85
	ε Aquarii -	7.49.34	49.55,5	50.16,9	—	51. 0	7.50.17	7.50.04,50
	η Capricorni	8. 5.41,6	6. 3,9	6.26,3	6.49,2	7.11,8	8. 6.26,52	8. 6.13,77
	α Equulei -	8.18.25,7	18.47	19. 8	19.29,4	19.50,4	8.19. 8,08	8.18.55,28
	ε Capricorni	8.38.26,9	38.49	39.11,8	39.34,2	39.56,9	8.39.11,77	8.38.58,87
	α Aquarii -	9. 8. 0	8.21	8.42	9. 3,1	9.24,2	9. 8.42,05	9. 8.29,15
	γ Aquarii -	9.23.46,3	24. 7,4	24.28,5	24.49,7	25.11	9.24.28,57	9.24.15,47
	η Aquarii -	9.37.29,2	37.50,3	38.11,2	38.32,4	38.53,8	9.38.11,35	9.37.58,10

Date.	Stars.	1.	2.	Merid. wire. 3.	4.	5.	Mean Chronometer.	Clock.
		h. m. s.	m. s.	m. s.	m. s.	m. s.	h. m. s.	h. m. s.
5	☉'s 1st limb	11.46.50,7	47.12	47.33	47.545	48.15,7	11.48.37,54	11.48. 8,64
	☉'s 2d limb	11.48.59,5	49.20,6	49.41,8	50. 3 1	50.24,5		
	σ Aquilæ -	6. ——	—	34.59	35.20,5	35.41,5	6.34.59,05	6.34.27,35
	α Aquilæ -	6.45.56,4	46.17,7	46.39	47. 0,5	47.21,8	6.46.39,07	6.46. 7,22
	θ Aquilæ -	7. 5.53,4	6.14,5	6.35,6	6.56,8	7.18	7. 6.35,65	7. 6. 3,75
	ι Aquarii -	7.41.40,6	42. 2	42.23,2	42.45	43. 6,3	7.42.23,38	7.41.51,28
	α Aquarii -	9. 0. 6	0.27,2	0.48	1. 9,1	1.30,5	9. 0.48,13	9. 0.15,68
	γ Aquarii	9.15.52,7	16.13,7	16.34,9	16.56	17.17	9.16.34,87	9.16. 2,27
	η Aquarii -	9.29.35,3	29.56,5	30.17,4	30.38,9	31. 0	9.30.17,62	9.29.44,92
6	☉'s 1st limb	11.46.30,5	46.51,9	47.13	47.34,6	47.55,9	11.48.17,66	11.47.40,36
	☉'s 2d limb	11.48.39,7	49. 1	49.22	49.43,4	50. 4,7		
	σ Aquilæ -	6.30.18,8	30.39,9	31. 1	31.22,3	31.43,4	6.31. 1,07	6.30.20,82
	α Aquilæ -	6.41.58,3	42.19,5	42.40,7	43. 2,2	43.23,8	6.42.40,87	6.42. 0,57
	θ Aquilæ -	7. 1.55,4	2.16,3	2.37,5	2.58,7	3.19,9	7. 2.37,55	7. 1.57,15
	ι Aquarii -	7.37.42,4	38. 4	38.25,2	38.47	39. 8,3	7.38.25,35	7.37.44,75
	α Equulei -	8. 6.33,8	6.55	7.16	7.37,4	7.58,7	8. 7.16,15	8. 6.35,35
	ι Capricorni	8.26.35,3	26.57,8	27.20	27.43	28. 5,5	8.27.20,27	8.26.39,37
	α Aquarii -	8.56. 8	56.29,4	56.50,2	57.11,4	57.32,8	8.56.50,33	8.56. 9,23
	γ Aquarii -	9.11.54,8	12.16	12.36,9	12.58	13.19,2	9.12.36,97	9.11.55,72
	η Aquarii -	9.25.37,7	25.58,7	26.19,5	26.41	27. 2	9.26.19,73	9.25.38,43
8	☉'s 1st limb	11.45.52,8	46.14	46.35	46.56,8	47.17,9	11.47.39,78	11.46.45,38
	☉'s 2d limb	11.48. 1,8	48.23	48.44	49. 5,5	49.27		
	σ Aquilæ -	6. ——	—	—	23.27	23.48	6.23. 5,67	6.22. 8,92
	θ Aquilæ -	6.53.58,9	54.20,5	54.41,4	55. 3	55.24	6.54.41,53	6.53.44,63
	ι Aquarii -	7.29.47	—	30.30	—	31.13	7.30.30	7.29.32,8
	α Equulei -	7. ——	—	—	59 42	60. 2,9	7.59.20,58	7.58.23,28
	ι Capricorni	8.18.39,7	19. 2,2	19.24,5	19.47,2	20. 9,8	8.19.24,65	8.18.27,2
	α Aquarii -	8.48.12,7	48.33,5	48.54,7	49.16	49.37	8.48.54,77	8.47.57,07
	η Aquarii -	9.17.42	18. 3	18.24	18.45,4	19. 6,5	9.18.24,17	9.17.26,37

Transits observed at Arbury Hill.

Date.	Stars.	1.	2.	Merid. wire. 3.	4.	5.	Mean Chronometer.	Clock.
Oct. 21	☉'s 1st limb	11.42.46,8	43. 8,2	43.29,9	43.51,1	44.13	11.44.35,39	11.44.28,39
	☉'s 2d limb	11.44.58	45.19,4	45.41	46. 2,5	46.24		
	σ Aquilæ -	5.31. 5,5	31.26,5	31.47,7	32. 9	32.30,2	5.31.47,73	5.31.39,53
	α Aquilæ -	5.42.44,5	43. 6	43.27,3	43.49	44.10,1	5.43.27,37	5.43.19,17
	θ Aquilæ -	6. 2.42,4	3. 3,8	3.24,8	3.46	4. 7	6. 3.24,8	6. 3.16,55
25	σ Aquilæ -	5.15.17	15.38,4	15.59,3	16.21	16.42	5.15.59,5	5.15.30,75
	α Aquilæ -	5.26.56,4	27.18	27.39	28. 0,6	28.22	5.27.39,17	5.27.10,42
	θ Aquilæ -	5.46.54,3	47.15,4	47.36,4	47.58	48.19	5.47.36,58	5.47. 7,78
26	☉'s 1st limb	11.42. 0,5	42.22	42.43,6	43. 5,5	43.27	11.43.49,83	11.43.17,93
	☉'s 2d limb	11.44.12,5	44.34,3	44.56	45.17,7	45.39,2		
	σ Aquilæ -	5.11.19,5	11.40,6	12. 1,9	12.23,1	12.44,4	5.12. 1,9	5.11.29,1
	α Aquilæ -	5.22.59	23.20,3	23.41,4	24. 3	24.24,4	5.23.41,58	5.23. 8,78
	θ Aquilæ -	5.42.56,5	43.18	43.39	44. 0	44.21,2	5.43.38,95	5.43. 6,05

Transits observed at Shanklin Farm.

Date.	Stars.	1.	2.	Merid. wire. 3.	4.	5.	Mean Chronometer.	Clock.
		h. m. s.	m. s.	m. s.	m. s.	m. s.	h. m. s.	h. m. s.
1819. May 10	Regulus -	6.51.42,2	52. 4	52.25,5	52.47,2	—	6.52.25,55	6.52.37,32
11	⊙'s 1st limb	11.58.51,7	59.14	59.36,2	59.58,5	60.20,5	0. 0.42,86	0. 0.49,49
	⊙'s 2d limb	0. 1. 5	1.27,3	1.49,6	2.11,8	2.34		
12	*d* -	9. 10.41	11. 3,3	11.25,5	11.48	12.10,5	9.11.25,63	9.11.21,26
	ε Virginis -	9. 37.45	38. 6,8	38.28	38.49,8	39.11,3	9.38.28,15	9.38.24,16
	α Virginis -	10. 0.10,7	0.32,2	0.53,5	1.15	1.36,5	10. 0.53,57	10. 0.49,30
	τ Bootæ -	10.23. 6,5	23.28,7	23.51	24.13,2	24.35,5	10.23.50,98	10.23.46,29
	η Bootæ -	10.30.29,3	30.51,8	31.14	31.36,5	31.59	10.31.14,1	10.31. 9,37
	Arcturus -	10.51.46	52. 9	53.31	53.58,8	53.16	10.52.31,13	10.52.26,25
13	⊙'s 1st limb	11.58.44,6	59. 7	59.29,2	59.51,8	60.14	0. 0.36,11	0. 0.26,89
	⊙'s 2d limb	0. 0.58,3	1.20,5	1.43	2. 5,2	2.27,5		
	Regulus -	6.39.49	40.11	40.32,5	40.54,2	41.15,8	6.40.32,5	6.40.21,23
14	⊙'s 1st limb	11.58.41,8	59. 4	59.26,5	59.48,8	60.11,0	0. 0.33,31	0. 0.16,44
	⊙'s 2d limb	0. 0.55,5	1.18	1.40	2. 2,5	2.25		
15	⊙'s 1st limb	11.58.39,2	59. 2	59.24	59.46,7	60. 9	0. 0.31,18	0. 0. 6,51
	⊙'s 2d limb	0. 0.53,4	1.15,8	1.38,2	2. 0,5	2.23		
	Regulus -	6.31.53,8	32.15,5	32.37	32.58,7	33.20,2	6.32.37,03	6.32.10,35
16	⊙'s 1st limb	11.58.37,5	59. 0	59.22,5	59.45	60. 7	0. 0.29,43	11.59.57,71
	⊙'s 2d limb	0. 0.51,5	1.14	1.36,5	1.59	2.21,3		
	Regulus -	6.27.56,0	28.17,8	28.39,5	29. 1	29.22,5	6.28.39,28	6.28. 5,65
	d -	8.54.50,3	55.13	55.35	55.57,5	56.20	8.55.35,13	8.55. 0,74
	ε Virginis -	9.21.54,3	22.16	22.37,3	22.59,1	23.20,5	9.22.37,41	9.22. 2,83
	α Virginis -	9.44.20	44.41,5	45. 2,8	45.24,2	45.45,6	9.45. 2,82	9.44.28,08
	τ Bootæ -	10. 7.15,7	7.37,7	8. 0	8.22,2	8.44,5	10. 8. 0,02	10. 7.25,28
	η Bootæ -	10.14.38,7	15. 1	15.23,3	15.45,7	16. 8,2	10.15.23,37	10.14.48,58
	Arcturus -	10.35.55,4	36.18	36.40,2	37. 3	37.25,2	10.36.40,33	10.36. 5,44

Comparisons of the Clock with the Chronometer.

Date.	Chronometer.	Clock.	Clock fast.
	h. m. s.	h. m. s.	m. s.
July 22, P. M.	5.19.10,25	5.24.28	5.17,75
	6.10.40,8	6.16. 0	5.19,20
	9.53.20	9.58.47	5.27
	10.16.10	10.21.38	5.28
	10.34.31,5	10.40. 0	5.28,5
	21.49.45,5	21.55.37,3	5.51,8
	22.41. 0,25	22.46.54	5.53,75
24	0.10.50,75	0.17.38	6.47,25
25	9.17.40	9.25.38	7.58
	9.41. 0,8	9.49. 0	7.59,2
	10. 3.25,25	10.11.25	7.59,75
	10.22.20,5	10.30.21	8. 0,5
26	0.13.28,5	0.22. 1	8.32,5
28	9.31.49,25	9.42. 0	10.10,75
	0.12. 6	0.22.23	10.17
	5.49.30,25	6. 0. 0	10.29,75
	9. 6.30	9.17. 7	10.37
	9.29.50	9.40.28	10.38
	9.51. 0,25	10. 1.39	10.38,75
	10.10. 5,5	10.20.45	10.39,5
August 5.	9. 4.40	9. 5.42	1. 2
	9.27.40,25	9.28.43	1. 2,75
	9.46.20	9.47.23	1. 3
	10.24.41	10.25.45	1. 4
	10.44. 0,5	10.45. 5	1. 4,5
	11. 5. 0	11. 6. 5	1. 5
6	0.22.59,8	0.24.22	1.22,2
	8.38. 5,25	8.39.39	1.33,75
7	0.16.40,25	0.18.36	1.55,75
8	0.16.45	0.19.18	2.33
	5.15.18,5	5.18. 0	2.41,5
	8.31. 0	8.33.47	2.47
	8.52.15,5	8.55. 3	2.47,5
	9.34.20,3	9.37. 9	2.48,7
	10.48.50,25	10.51.41	2.50,75
10	0.16.15	0.20. 8	3.53
	5. 3.35,4	5. 7.37	4. 1,6
	8.22.20,4	8.26.28	4. 7,6
	8.44. 0,75	8.48. 9	4. 8,25
	9. 7. 0	9.11. 9	4. 9
	9.26.15,5	9.30.25	4. 9,5
	9.58.45,5	10. 2.56	4.10,5
	10.40.10	10.44.22	4.12
11	8.18. 0,5	8.22.52	4.51,5
	8.40.14,75	8.45. 7	4.52,25
	9. 5. 0	9. 9.53	4.53
	9.22. 0,5	9.26.54	4.53,5

Date.	Chronometer.	Clock.	Clock fast.
	h. m. s.	h. m. s.	m. s.
August 11	9.54. 6,5	9.59. 1	4.54,5
	10.16.19,75	10.21.15	4.55,25
	10.36.50,25	10.41.46	4.55,75
12	0.15.45,4	0.21. 6	5.20,6
	4.57. 0,25	5. 2.29	5.28,75
	8.13.25,25	8.19. 0	5.34,75
	8.36. 0,5	8.41.36	5.35,5
	9. 1. 0,5	9. 6.37	5.36,5
	9.20.20	9.25.57	5.37
	9.50. 5	9.55.43	5.38
	10.11.55,5	10.17.34	5.38,5
	10.31.49,75	10.37.29	5.39,25
			Slow.
13	0.17.30,75	0.17. 8	0.22,75
	4.51. 0,5	4.50.46	0.14,5
	8.10.20,4	8.10.12	0. 8,4
			Fast.
14	0.15.51,5	0.16.12	0.20,5
	8. 6.25,25	8. 7. 0	0.34,75
	8.29.41,5	8.30.17	0.35,5
	8.51.20	8.51.56	0.36
	9.10.15,4	9.10.52	0.36,6
	10. 5.32,5	10. 6.11	0.38,5
	10.21.10	10.21.49	0.39
15	0.15.29,75	0.16.35	1. 5,25
	4.43.51,75	4.45. 5	1.13,25
	8. 3.54,75	8. 5.14	1.19,25
	8.24. 0	8.25.20	1.20
	8.47.15,25	8.48.36	1.20,75
	9. 6.15,5	9. 7.37	1.21,5
16	0.15. 0,25	0.16.49	1.48,75
	4.40.29,9	4.42.27	1.57,1
	7.58.56,75	8. 1. 0	2. 3,25
	8.43.19,5	8.45.24	2. 4,5
	9. 3.34,8	9. 5.40	2. 5,2
	10.13. 0,5	10.15. 8	2. 8,5
17	0.15.24,9	0.17.58	2.33,1
	7.56.41,12	7.59.28,5	2.47,38
	8.16. 5	8.18.53	2.48
	8.39.10,25	8.41.59	2.48,75
	8.58.11,5	9. 1. 1	2.49,5
	9.51.59,9	9.54.51	2.51,1
	10. 9.30,4	10.12.22	2.51,6
18	4.32.49,75	4.36.14	3.24,25
	8.12.34,8	8.16. 6	3.31,2
	8.35. 5	8.38.37	3.32
	8.54. 0,5	8.57.33	3.32,5
19	0.14.34,75	0.18.35	4. 0,25
			Slow.
31	7.47.49, 9	7.47.19	0.30,9

Date.	Chronometer.	Clock.	Clock slow.
	h. m. s.	h. m. s.	m. s.
August 31	9.56. 5,5	9.55.37	0.28, 5
	10.41.39,75	10.41.12	0.27,75
	10.56. 0,5	10.55.33	0.27,5
	11.16. 0	11.15.33	0.27
	11.29. 9,8	11.28.43	0.26,8
	11.46.40,5	11.46.14	0.26,5
			Fast.
September 2	0.13.15,3	0.13.35	0.19,7
	9.45. 0,8	9.45.32	0.31,2
	10. 4. 0,4	10. 4.32	0.31,6
	10.33.49,75	10.34.22	0.32,25
	10.48.10,4	10.48.43	0.32,6
	11.19.44,75	11.20.18	0.33,25
	12. 4.24,75	12. 4.49	0.34,25
4	9.38. 4,75	9.39.35	1.30,25
	9.58. 0,25	9.59.31	1.30,75
	10.24.45,5	10.26.17	1.31,5
	10.40.40,25	10.42.12	1.31,75
	10.53. 0	10.54.32	1.32
	11.12. 0,5	11.13.33	1.32,5
	11.31. 0	11.32.33	1.33
	11.48. 9,75	11.49.43	1.33,25
	11.56. 5,5	11.57.39	1.33,5
5	0.11.15,2	0.13. 5	1.49,8
6	0.11.49,8	0.14.12	2.22,2
			Slow.
8	10. 8.30	10. 4.46	3.44
	10.28. 5,5	10.24.42	3.43,5
	10.37.15,3	10.33.32	3.43,3
	10.55.49,9	10.52. 7	3.42,9
	11.21. 0,3	11.27.18	3.42,3
	11.40. 9,8	11.36.28	3.41,8
	11.58.41,4	11.55. 0	3.41,4
10	10. 6. 0,5	10. 3.28	2.32,5
	10.16.30,25	10.13.58	2.32,25
	10.30. 5	10.27.33	2.32
	11.13.30,8	11.11. 0	2.30,8
	11.32.50,3	11.30.20	2.30,3
	11.50. 9,9	11.47.40	2.29,9
12	9.54.20,4	9.53. 2	1.18,4
	10. 8.50	10. 7.32	1.18
	10.41. 0,25	10.39.43	1.17,25
	11. 4. 0,75	11. 2.44	1.16,75
	11.23.40,25	11.22.24	1.16,25
	11.42. 0,75	11.40.45	1.15,75
14	9.45. 4,9	9.44.56	0. 8,9
	10. 5.40,2	10. 5.32	0. 8,2
	10.17.40	10.17.32	0. 8
	10.32. 4,75	10.31.57	0. 7,75
	10.56 30	10.56.23	0. 7
	11.15.26,5	11.15.20	0. 6,5

Date.	Chronometer.	Clock.	Clock slow.
	h. m. s.	h. m. s.	m. s.
September 14	11.34.19,9	11.34.14	0. 5,9
October 2	6.49. 9,75	6.49. 7	0. 2,75
	7. 1. 2,75	7. 1. 0	0. 2,75
	7.21. 2,8	7.21. 0	0. 2,8
	8.27. 3,25	8.27. 0	0. 3,25
	8.48. 3,3	8.48. 0	0. 3,3
	9.15. 3,4	9.15. 0	0. 3,4
	9.31. 3,5	9.31. 0	0. 3,5
3 A. M.	11.54. 9,3	11.54. 0	0. 9,3
P. M.	6.45.12,25	6.45. 0	0.12,25
	6.57.12,25	6.57. 0	0.12,25
	7.16.12,4	7.16. 0	0.12,4
	7.54.12,5	7.54. 0	0.12,5
	8. 9.12,75	8. 9. 0	0.12,75
	8.22.12,8	8.22. 0	0.12,8
	8.42.12,9	8.42. 0	0.12,9
	9.11.30	9.11.17,1	0.12,9
	9.29.13,1	9.29. 0	0.13,1
	9.41.13,25	9.41. 0	0.13,25
5 A. M.	11.52.28,9	11.52. 0	0.28,9
P. M	6.37.31,7	6.37. 0	0.31,7
	6.43.31,8	6.43. 0	0.31,8
	7. 9.31,9	7. 9. 0	0.31,9
	7.46.32	7.46. 0,1	0.32,1
	8. 1.32,25	8. 1. 0	0.32,25
October 5	9. 4.32,45	9. 4. 0	0.32,45
	9.18.32,6	9.18. 0	0.32,6
	9.32.32,7	9.32. 0	0.32,7
6 A. M.	11.51.37,3	11.51. 0	0.37,3
P. M.	6.32.40,25	6.32. 0	0.40,25
	6.44.40,3	6.44. 0	0.40,3
	7. 3.40,4	7. 3. 0	0.40,4
	7.40.40,6	7.40. 0	0.40,6
	8. 9.40,8	8. 9. 0	0.40,8
	8.29.40,9	8.29. 0	0.40,9
	8.59.41,1	8.59. 0	0.41,1
	9.14.41,25	9.14. 0	0.41,25
	9.28.41,3	9.28. 0	0.41,3
7 A. M.	11.51.45,6	11.51. 0	0.45,6
8 A. M.	11.51.54,4	11.51. 0	0.54,4
P. M.	6.24.56,75	6.24. 0	0.56,75
	6.57.56,9	6,57. 0	0.56,9
	7.33.57,2	7.33. 0	0.57,2
	8. 1.57,3	8. 1. 0	0.57,3
	8.21.57,45	8.21. 0	0.57,45
	8.50.57,7	8.50. 0	0.57,7
	9.22. 57,8	9.22. 0	0.57,8
21 A. M.	11.49. 7	11.49. 0	0. 7
P. M.	5.35. 8,2	5.35. 0	0. 8,2
	5.46. 8,2	5.46. 0	0. 8,2

Date.	Chronometer.	Clock.	Clock slow.
	h. m. s.	h. m. s.	m. s.
October 21	6. 6. 8,25	6. 6. 0	0. 8,25
	6.19. 8,25	6.19. 0	0. 8,25
October 25	5.19.28,75	5.19. 0	0.28,75
	5.30.28,75	5.30. 0	0.28,75
	5.50.28,8	5.50. 0	0.28,8
	6.55.28,95	6.55. 0	0.28,95
	7.10.29,05	7.10. 0	0.29,05
	7.44.29,2	7.44. 0	0.29,2
	7.59.29,2	7.59. 0	0.29,2
	8.14.29,25	8.14. 0	0.29,25
26 A. M.	11.48.31,9	11.48. 0	0.31,9
P. M.	5.15.32,8	5.15. 0	0.32,8
	5.26.32,8	5.26. 0	0.32,8
	5.50.32,9	5.50. 0	0.32,9
			Fast.
1819. May 10	6.56.48,25	6.57. 0	0.11,75
11	0. 4.53,4	0. 5. 0	0. 6,6
			Slow.
12	8.28. 4,25	8.28. 0	0. 4,25
	9.16. 4,4	9.16. 0	0. 4,4
	9.46. 4,4	9.46. 0	0. 4,4
	10. 4. 4,3	10. 4. 0	0. 4,3
	10.34. 4,75	10.34. 0	0. 4,75
	10.55. 4,9	10 55. 0	0. 4,9
13	0. 5. 9,25	0. 5. 0	0. 9,25
	6.45.11,3	6.45. 0	0.11,3
14	0. 4.16,9	0. 4. 0	0.16,9
15	0. 4.24,7	0. 4. 0	0.24,7
	6.35.26,7	6 35. 0	0.26,7
16	0. 4.31,75	0. 4. 0	0.31,75
	6.31.33,75	6.31. 0	0.33,75
	8.57.34,4	8.57. 0	0.34,4
	9.25.34,6	9.25. 0	0.34,6
	9.47.34,75	9.47. 0	0.34,75
	10.17.34,8	10.17. 0	0.34,8
	10.38.34,9	10.38. 0	0.34,9

Observations for the error of the Chronometer.

UNST, 1818, 23d July, P. M. ☉'s U. L.

Chronometer.		Level.		Readings, &c.		
	h. m s.					° ′ ″
	4.21.24,5	+ 7	— 3	First Vernier		239.32.15
	4.24.29,5	+ 5	— 5	Second		5
	4.26.46,0	+10	+ 4	Third		5
	4.28. 1,5	+ 9	+ 0	Fourth		10
Mean	4.25.10,4	+31	— 4	Mean		239.32. 8,7
True time	4.24.23,3			Level	+	32,4
				Index	+	18,0
Chron. fast	47,1					4)239.32.59,1
$\frac{(+31-4)''}{2}\times 2{,}4 = +32{,}4''$				Observed Z. D.		59.53.14,8
				Ref. and Parall.	+	1.32,3
				Semidiam.	+	15.46,4
				True Z. D.		60.10.33,5

UNST, 23rd July, P. M. ☉'s U. L.

Chronometer.		Level.		Readings, &c.		
	h. m. s.					° ′ ″
	4.31.55	+ 6	— 1	First Vernier		243.58.10
	4.33.16	+ 4	— 2	Second		58. 0
	4.35.32,5	+ 9	+ 4	Third		57.50
	4.37. 0,5	+ 5	+ 0	Fourth		58.15
Mean	4.34.26,0	+24	+ 1	Mean		243.58.3,7
True time	4.33.37,9			Level	+	30,0
				Index	+	18,0
Chron. fast	48,1					4)243.58.51,7
$\frac{(+24+1)''}{2}\times 2{,}4 = +30{,}0''$				Observed Z. D.		60.59.42,9
				Ref. and Parall.	+	1.36,8
				Semidiam.	+	15.46,4
				True Z. D.		61.17. 6,1

From the mean of the above observations, the chronometer appears to be $47^{s},6$ too fast, and the rate being $-1^{s},81$, we have $47^{s},9$ for its error too fast at noon.

PORTSOY, 1818, 3rd August, P. M. ☉'s U. L.

Chronometer.		Level.		Readings, &c.		
	h. m. s.					° ′ ″
	4. 8.35	+ 4	— 2	First Vernier	-	234.26.55
	4. 9.50,5	— 1	— 6	Second -	-	45
	4.11. 7	+ 2	— 4	Third -	-	40
	4.12. 4,5	+ 5	— 0	Fourth -	-	60
Mean - -	4.10.24,2	+10	—12	Mean -	-	234.26.50
True time -	4. 2.31,3			Level -	- —	2,4
				Index -	- +	18,0
Chron. fast - -	7.52,9					4)234.27. 5,6
$\frac{(10-12)}{2}\times 2'',4 = -2'',4$				Observed Z. D.	-	58.36.46,4
				Ref. and Parall.	- +	1.24,7
				Semidiam.	- +	15.47
				True Z. D.	-	58.53.58,1

PORTSOY, 3rd August, P. M. ☉'s U. L.

Chronometer.		Level.		Readings, &c.		
	h. m. s.					° ′ ″
	4.15.56,5	+ 4	+ 2	First Vernier	-	238.18.40
	4.17. 9	+ 4	+ 1	Second -	-	25
	4.18.29,5	+ 5	+ 3	Third -	-	30
	4.20. 5,5	+ 1	— 2	Fourth -	-	50
Mean - -	4.17.55,1	+14	+ 4	Mean -	-	238.18.36,6
True time - -	4.10. 3,4			Level -	- +	21,6
				Index -	- +	18,0
Chron. fast - -	7.51,7					4) 238.19.16,2
$\frac{(+14+4)}{2}\times 2'',4 = 21'',6$				Observed Z. D.	-	59.34.49,0
				Ref. and Parall.	- +	1.30,4
				Semidiam	- +	15.47
				True Z. D.	-	59.52. 6,4
				Sun rather obscure during some of these observations.		

From the mean of the above observations, the chronometer appears to be $7^{m}.52^{s},3$ too fast, and the rate being $-1^{s},7$ we have the chronometer $7^{m}.52^{s},58$ too fast at apparent noon.

LEITH FORT, 1818, 17th September, A. M. ☉'s U. L.

Chronometer.		Level.		Readings, &c.		
	h. m. s.					° ′ ″
	7.36.34	+24	—17	First Vernier	-	297.25.25
	7.38.26	+22	—19	Second	- -	25.40
	7.41.16	+20	—21	Third	- -	25.25
	7.43. 1	+22	—15	Fourth	- -	25.15
Mean - -	7.39.49,2	+88	—72	Mean	- -	297.25.26,2
True time -	7.31. 7,6			Level	- - +	19,2
				Index	- - +	18
Chron. fast -	8.41,6					4) 297.26.3,4
				Observed Z. D.		74.21.30,85
$\frac{(+88-72)}{2}\times 2{,}4'' = +19{,}2''$				Ref. and Parall.	+	3.16,6
				Semidiam. -	+	15.57,3
				True Z. D.	-	74.40.44,75

LEITH FORT, 17th September, A. M. ☉'s U. L.

Chronometer.		Level.		Readings, &c.		
	h. m. s.					° ′ ″
	7.49. 4	+20	—20	First Vernier	-	291.19.55
	7.50.19	+18	—20	Second	- -	19.45
	7.52.19,5	+25	—13	Third	- -	19.55
	7.54.16,5	+16	—22	Fourth	- -	19.55
Mean - -	7.51.29,8	+79	—75	Mean	- -	291.19.52,5
True time -	7.42.48,2			Level	- - +	4,8
				Index	- +	18
Chron. fast -	8.41,6					4)291.20.15,3
				Observed Z. D.		72.50. 3,85
$\frac{(+79-75)}{2}\times 2{,}4'' = +4{,}8''$				Ref. and Parall.	+	2.58
				Semidiam.	- - +	15.57,3
				True Z. D.	-	73. 8.59,15

From the above observations the chronometer appears to be 8^m.41^s,6 too fast, and the rate being—1^s,85, we have the chronometer 8^m.42^s,18 too fast at apparent noon.

ARBURY HILL, at the Pendulum Station, 1818, August 18th, P. M. ☉'s U. L.

Chronometer.		Level		Readings, &c.		
	h. m. s.					° ′ ″
	3.4. 7	+ 9	—17	First Vernier	-	299.46.55
	3.5.31	+11	—12	Second	-	40
	3.7.34	+14	— 9	Third	-	50
	3.8.51	+11	—13	Fourth	-	45
Mean - -	3.6.30,7	+45	—51	Mean -	-	299.46.47,5
True time -	3.6.44,5			Level -	- —	7,2
				Index -	- +	18,0
Chronom. slow -	13,8					4)299.46.58,3
				Observed Z. D.	-	74.56.44,5
				Ref. and Parall.	+	3.24,3
				Semidiam. -	+	16. 6,0
				True Z. D.	-	75.16.14,9

$$\frac{(+45-51)}{2}\times 2'',4=-7'',2$$

ARBURY HILL, at the Pendulum Station, August 18th, P. M. ☉'s U. L.

Chronometer.		Level.		Readings, &c.		
	h. m. s.					° ′ ″
	3.13.48	+14	— 7	First Vernier	-	151.57. 5
	3.16.12	+12	— 9	Second -	-	56.30
				Third -	-	56.35
Mean -	3.15. 0	+26	—16	Fourth -	-	56.45
True time -	3.15.14,8					
				Mean -	-	151.56.43,7
Chronom. slow -	14,8			Level -	- +	12,0
				Index -	- +	18,0
						2)151.57.13,7
				Observed Z. D.	-	75.58.36,8
				Ref. and Parall.	- +	3.48,2
				Semidiam. -	+	16. 6,0
				True Z. D.	-	76.18.31,0

$$\frac{(+26-16)}{2}\times 2'',4=+12'',0$$

From the mean of the above observations the chronometer appears to be 14^s,3 too slow; the daily rate being — 1^s,26.

SHANKLIN FARM, 10th May, 1819, A. M, O's U. L.

Chronometer.		Level.		Readings, &c.		
	h. m. s.					° ′ ″
	8.39.32	+18	—15	First Vernier	-	204.40.35
	8.41. 3	+11	—19	Second	- -	20
	8.42.56	+12	—19	Third	- -	10
	8.44.44	+13	—17	Fourth	- -	30
Mean - -	8.42. 3,75	+54	—70	Mean	- -	204.40.23,7
True time -	8.37.24,90			Level	- - —	19,2
				Index	- - +	13,0
Chron. fast -	4.38,85				4)	204.40.17,5
$\frac{(+54-70)}{2}\times 2{,}4'' = -19{,}2''$				Observed Z. D.	-	51.10. 4,35
				Ref. and Parall.	+	1. 5,0
				Semidiam.	- +	15.51,4
				True Z. D.	-	51.27. 0,75

SHANKLIN FARM, 10th May, A. M. O's U. L.

Chronometer.		Level.		Readings, &c.		
	h. m. s.					° ′ ″
	8.50.33	+20	—10	First Vernier	-	197.31.50
	8.52.14	+17	—13	Second	- -	35
	8.56.23	+22	— 5	Third	- -	30
	8.57.57	+14	—14	Fourth	- -	50
Mean - -	8.54.16,75	+73	—42	Mean	- -	197.31.41,2
True time -	8.49.36,90			Level	- - +	37,2
				Index	- - +	13,0
Chron. fast -	4.39,85				4)	197.32.31,4
$\frac{(+73-42)}{2}\times 2{,}4'' = +37{,}2''$				Observed Z. D.	-	49.23. 7,85
				Ref. and Parall.	+	1. 1,2
				Semidiam.	- +	15.51,4
				True Z. D.	-	49,40. 0,45

SHANKLIN FARM, 10th May, A.M. O's U. L.

Chronometer.		Level.		Readings, &c.		
	h.m.s.					° ′ ″
	9.3. 1	+21	— 6	First Vernier -		191.30. 0
	9.4. 9	+ 9	—20	Second - -		29.30
	9.5.37	+21	— 6	Third - -		29.40
	9.6.36	+20	— 6	Fourth - -		30. 0
Mean - -	9.4.50,75	+71	—38	Mean - -		191.29.47,5
True time -	9.0.10,40			Level - -	+	39,6
				Index -	+	13,0
Chron. fast. -	4.40,35					4)191.30.40,1
				Observed Z. D. -		47.52.40,05
$\frac{(+71-38)}{2}\times 2{,}4'' = +39{,}6''$				Ref. and Parall.	+	58,5
				Semidiam. -	+	15.51,4
				True Z. D. -		48. 9.30,0

Observations of Coincidences.

1818, June 13, A. M. at Mr. Browne's house, Portland-place, LONDON. Barometer 29,9 inches, clock gaining 1',5 in a mean solar day.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed Vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
71,2	10. 5. 9	1,38	1,35	489			2,98	
	13.18	1,33	1,30	490			2,77	
	21.28	1,27	1,25	491			2,56	
	29.39	1,23	1,20	490			2,36	
	37.49	1,17	1,15	491			2,17	
	46. 0	1,13	1,10	491			1,98	
	54.11	1,08	1,05	490			1,80	
	11. 2.21	1,03	1,00	493			1,64	
	10.34	0,98	0,96	490			1,51	
	19.44	0,95	0,93	490			1,42	
72,0	26.56	0,92						
71,6	Mean			490,5	488,5	86049,20	2,12	86051,32

June 14, A. M. Barometer 30,0 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed Vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
69,3	10.27.30	1,39	1,36	490			3,03	
	35.40	1,33	1,30	491			2,77	
	43.51	1,28	1,25	491			2,56	
	52. 2	1,23	1,20	490			2,36	
70,3	11. 0.12	1,17	1,15	492			2,17	
	8.24	1,13	1,10	491			1,98	
	16.35	1,08	1,05	492			1,80	
	24.47	1,03	1,01	491			1,67	
	32.58	0,99	0,97	422			1,54	
	41.10	0,96	0,94	493			1,45	
70,6	49.23	0,92						
70,1	Mean			491,3	489,3	86049,77	2,13	86051,90

June 15, A. M. LONDON.

Barometer 30,05 inches, clock gaining 1^s,5.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
69,6	10. 3.10	1.34						
	11.20	1.29	1,31	490			2,81	
	19.31	1.23	1,26	491			2,60	
	27.42	1.18	1,20	491			2,36	
	35.54	1.13	1,15	492			2.17	
	44. 5	1.09	1,11	491			2.02	
70,3	52.17	1.05	1,07	492			1,88	
69,9	Mean			491,17	489,17	86049,68	2.31	86051,99

June 16, A. M. Barometer 29,95 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
70,3	9.58.13	1,26						
	10. 6.24	1,22	1,24	491			2,52	
	14.34	1,16	1,18	490			2,28	
	22.46	1,12	1,14	492			2,13	
	30.57	1,06	1,09	491			1,95	
	39. 9	1,02	1,04	492			1,77	
	47.21	0,98	1,00	492			1,64	
	55.33	0,94	0,96	492			1,51	
	11. 3.45	0,90	0,92	492			1,39	
	11.58	0,87	0,88	493			1,27	
70,8	20.10	0,82	0,84	492			1,15	
70,5	Mean			491,7	489, 7	86050,06	1,76	86051,82

July 23, P. M. at Unst.

Clock gaining 50',63 in a mean solar day. Barometer 30,0 inches.

Temp.	Time of Coincidence.	Arc of vibration.	Mean Arc.	Interval in Seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
58,0	0.44.47	1,25	1,21	481			2,40	
	52.48	1,18	1,16	481			2,20	
	1. 0.49	1,14	1,11	483			2,02	
	8.52	1,08	1,05	482			1,80	
	16.54	1,03	1,00	483			1,64	
	24.57	0,98	0,95	482			1,48	
	32.59	0,93	0,91	483			1,36	
	41. 2	0,90	0,87	483			1,24	
	49. 5	0,85	0,83	483			1,13	
	57. 8	0,82	0,80	482			1,05	
58,8	2. 5.10	0,78						
58,4	Mean			482,3	480,3	86092,15	1,63	86093,78
	July 23, P. M.				Barometer 30,3 inches.			
58,8	2. 9.54	1,21	1,18	481			2,28	
	17.55	1,16	1,13	481			2,10	
	25.56	1,11	1,08	481			1,91	
	33.57	1,06	1,03	481			1,74	
	41.58	1,01	0,99	482			1,61	
	50. 0	0,97	0,95	481			1,48	
	58. 1	0,94	0,92	482			1,39	
	3. 6. 3	0,90	0,87	482			1,24	
	14. 5	0,85	0,83	482			1,13	
	22. 7	0,82	0,80	482			1,05	
59,8	30. 9	0,79						
59,3	Mean			481,5	479,5	86091,55	1,59	86093,14

July 24, A. M. UNST.

Clock gaining 50',63. Barometer 29,9 inches.

Temp.	Time of Coincidence.	A c of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
56,7	8. 4.15	1,22	1,19	481			2,32	
	12.16	1,17	1,14	481			2,13	
	20.17	1,12	1,10	481			1,99	
	28.18	1,08	1,05	482			1,80	
	36.20	1,03	1,00	481			1,64	
	44.21	0,98	0,96	481			1,51	
	52.22	0,94	0,92	482			1,39	
	9. 0.24	0,91	0,89	483			1,30	
	8.27	0,87	0,85	482			1,18	
	16.29	0,83	0,81	483			1,08	
58,0	24.32	0,80						
57,3	Mean			481,7	479,7	86091,70	1,63	86093,33
	July 24, P. M.				Barometer, 29,82 inches.			
59,7	1. 2.36	1,21	1,17	481			2,24	
	10 37	1,14	1,12	479			2,06	
	18.36	1,10	1,07	481			1,88	
	26.37	1,05	1,03	480			1,74	
	34.37	1.02	0,99	481			1,60	
	42.38	0,97	0,95	481			1,48	
	50.39	0,93	0,91	480			1,36	
	58.39	0,89	0,87	481			1,24	
	2. 6.40	0,85	0,84	481			1,16	
	14.41	0,83	0,81	481			1,08	
59,8	22.42	0,79						
59,7	Mean			480,6	478,6	86090,87	1,58	86092,45

July 25, A. M. Unst.

Clock gaining 50',63. Barometer 29,84 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°					
57,00	7.41.34	1,20	1,17	481			2,24	
	49.35	1,14	1,12	481			2,06	
	57.36	1,10	1,07	481			1,88	
	8. 5.37	1,05	1,03	482			1,74	
	13.39	1,01	0,99	481			1,60	
	21.40	0,97	0,95	482			1,48	
	29.42	0,93	0,91	482			1,36	
	37.44	0,89	0,87	482			1,24	
	45.46	0,85	0,83	481			1,13	
	53.47	0,82	0,80	482			1,05	
58,4	9. 1.49	0,79						
57,7	Mean			481,5	479,5	86091,54	1,58	86093,12

July 25, P. M. Barometer 29,72 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
58,7	2. 0.27	1,21	1,19	480			2,32	
	8.27	1,17	1,14	480			2,13	
	16.27	1,11	1,08	480			1,91	
	24.27	1,06	1,03	479			1,74	
	32.26	1,01	0,99	481			1,60	
	40.27	0,98	0,95	480			1,48	
	48.27	0,93	0,91	480			1,36	
	56.27	0,90	0,88	482			1,27	
	3. 4.29	0,87	0,85	480			1,18	
59,3	12.29	0,83						
59,0	Mean			480,2	478,2	86090,57	1,67	86092,24

July 26, A. M. UNST.

Clock gaining 50",63. Barometer 29,95 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
57,1	7.42.47	1,13	1,10	480			1,98	
	50.47	1,08	1,06	480			1,84	
	58.47	1,04	1,02	481			1,71	
	8. 6.48	1,00	0,98	481			1,57	
	14,49	0,97	0,95	481			1,48	
	22.50	0,93	0,91	480			1,36	
	30 50	0,89	0,86	481			1,21	
	38 51	0,84	0,82	481			1,10	
	46.52	0,81	0,80	481			1,05	
	54.53	0,79	0,77	481			0,97	
58.6	9. 2.54	0,75						
47,8	Mean			480,7	478,7	86090,94	1,43	86092,37

Oil was now applied to the scapement without stopping the clock.

July 27, A. M.—Unst.

Clock gaining 50s,63. Barometer 29,95 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
56,4	7.45.32	1,14	1,11	479			2,02	
	53.31	1,09	1,06	480			1,84	
	8. 1.31	1,04	1,02	478			1,71	
	9.29	1,00	0,98	480			1,57	
	17.29	0,97	0,94	480			1,45	
	25.29	0,92	0,90	480			1,33	
	33.29	0,88	0,86	480			1,21	
	41.29	0,84	0,82	481			1,10	
	49.30	0,80	0,78	480			1,00	
	57.30	0,77	0,75	480			0,92	
57,3	9. 5.30	0,73						
56,8	Mean			479,8	477,8	86090,27	1,42	86091,69

July 27, P. M.

Barometer 30,0 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
57,2	1.29. 6	1,18	1,15	479			2,17	
	37. 5	1,13	1,10	478			1,98	
	45. 3	1,08	1,06	478			1,84	
	53. 1	1,04	1,01	480			1,68	
	2. 1. 1	0,98	0,97	481			1,54	
	9. 2	0,96	0,94	479			1,45	
	17. 1	0,92	0,90	480			1,33	
	25. 1	0,88	0,86	480			1,21	
	33. 1	0,84	0,83	480			1,13	
	41. 1	0,82	0,80	480,5			1,05	
57,2	49.01,5	0,78						
57,2	Mean			479,6	477,6	86090,08	1,54	86091,62

July 28, A. M.—UNST.

Clock gaining 50ˢ,63. Barometer 30,05 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
53,8	8. 2. 7	1,29						
	10. 7	1,13	1,21	480			2,40	
	18. 7	1,08	1,10	480			1,98	
	26. 7	1,03	1,05	480			1,80	
	34. 7	1,01	1.02	480			1,70	
	42. 8	0,96	0,98	481			1,57	
	50. 9	0,92	0,94	481			1,45	
	58. 9	0,88	0,90	480			1,33	
	9. 6.11	0,85	0,86	482			1,21	
	14.12	0,82	0,83	481			1,13	
54,8	22.14	0,78	0,80	482			1,05	
54,3	Mean			480,7	478,7	86090,95	1,56	86092,51
July 28, P. M.						Barometer 30,2 inches.		
57.6	2.12. 1	1,27						
	19.59	1,22	1,24	478			2,52	
	27 57	1,17	1,19	478			2,32	
	35.55	1,11	1,14	478			2,18	
	43.55	1,06	1,08	480			1,91	
	51.53	1,02	1,04	478			1,77	
	3. 9.53	0,98	1,00	480			1,64	
	7.52	0,93	0,95	479			1,48	
	15.53	0,89	0,91	481			1,36	
	23.53	0,85	0,87	480			1,24	
58,5	32.53	0,82	0,83	480			1,13	
58,0	Mean			479,2	477,2	86089,82	1,75	86091,57

August 6, A. M. at Portsoy.—1st Series.

Clock gaining 37',63 in a mean solar day. Barometer 29,95 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
64.8	7.38.22	1,16	1,14	488			2,13	
	46.30	1,12	1,09	489			1,95	
	54.39	1,07	1,05	488			1,80	
	8. 2.47	1,03	1,01	489			1,67	
	10.56	0,99	0,96	489			1,51	
	19. 5	0,94	0,92	489			1,39	
	27.14	0,90	0,88	489			1,27	
	35.23	0,87	0,85	490			1,18	
	43.33	0,84	0,82	489			1,10	
	51.42	0,80	0,78	489			1,00	
64,8	59.51	0,76						
64,8	Mean			488,9	486,9	86084,03	1,50	86085,53

August 6, P. M. Barometer 30,0 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
64,8	1. 0.42	1,23	1,19	486			2,32	
	8.48	1,16	1,14	486			2,13	
	16.54	1,12	1,08	487			1,91	
	25. 1	1,05	1,03	487			1,74	
	33. 8	1,02	1,00	487			1,64	
	41.15	0,98	0,95	487			1,48	
	49.22	0,93	0,91	487			1,36	
	57.29	0.89	0,87	487			1,24	
	2. 5.36	0,85	0,84	487			1,16	
	13.43	0,83	0,81	488			1,07	
65,7	21.51	0,79						
65,2	Mean			486,9	484,9	86082,58	1,61	86084,19

August 7, A. M. PORTSOY.—1st Series.

Clock gaining 37",63. Barometer 29,89 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
62,7	7.26.17	1,15						
	34 22	1,10	1,12	485			2,06	
	42.27	1,06	1,08	485			1,91	
	50.32	1,01	1,03	485			1,74	
	58.38	0,98	0,99	486			1,61	
	8. 6.44	0,94	0,96	486			1,51	
	14.49	0,89	0,91	485			1,36	
	22.55	0,85	0,87	486			1.24	
	31. 1	0,83	0,84	486			1,16	
	39. 7	0,79	0,81	486			1,08	
61,9	47.13	0,76	0,77	486			0,97	
62,3	Mean			485,6	483,6	86081,63	1,46	86083,09

August 7, P. M. Barometer 29,88 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
62,2	0.52. 9	1,19						
	1. 0.12	1,14	1,16	483			2,21	
	8.16	1,09	1,11	484			2,02	
	16.20	1,05	1,07	484			1,87	
	24.24	1,00	1,02	484			1,71	
	32.29	0,96	0,98	485			1,57	
	40.34	0,93	0,94	485			1,45	
	48.38	0,89	0,91	484			1,36	
	56.43	0,85	0,87	485			1,24	
	2. 4.47	0,82	0,83	484			1,13	
63,0	12 53	0,78	0,80	486			1,05	
62,6	Mean			484,4	482,4	86080,74	1,56	86082,30

August 8, A. M. Portsoy.—1st. Series.

Clock gaining 37",63. Barometer 30,05 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
58,6	7.39.46	1,21	1,18	482			2,28	
	47.48	1,15	1,13	483			2,10	
	55.51	1,12	1,09	483			1,95	
	8. 3.54	1,06	1,04	484			1,77	
	11.58	1,02	1,00	483			1,64	
	20. 1	0,98	0,96	484			1,51	
	28. 5	0,94	0,92	483			1,39	
	36. 8	0,90	0,88	484			1,27	
	44.12	0,86	0,84	484			1,16	
	52.16	0,83	0,81	484			1,08	
59,0	9. 0.20	0,79						
58,8	Mean			483,4	481,4	86080,00	1,61	86081,61
August 8, P. M.					Barometer 30,09 inches.			
60,0	1. 4.28	1,16	1,13	483			2,10	
	12.31	1,11	1,08	482			1,91	
	19.33	1,06	1,04	482			1,77	
	27.35	1,02	1,00	483			1,64	
	36.38	0,99	0,96	483			1,51	
	44.41	0,94	0,92	483			1,39	
	52.54	0,90	0,88	484			1,27	
	2. 0.48	0,86	0,84	483			1,16	
	8.51	0,83	0,81	483			1,08	
	16.54	0,79	0,77	483			0,97	
61,1	24.57	0,76						
60,5	Mean			482,9	480,9	86079,63	1,48	86081,11

Oil was applied to the scapement without stopping the clock.

August 9, A. M. PORTSOY.—1st Series.

Clock gaining 37',63. Barometer 30,04 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
60,3	7.34.10	1,17						
	42. 9	1,13	1,15	479			2,17	
	50. 9	1,08	1,10	480			1,98	
	58. 9	1,04	1,06	480			1,84	
	8. 6.10	1,00	1,02	481			1,71	
	14.11	0,95	0,97	481			1,54	
	22.11	0,92	0,93	480			1,42	
	30.12	0,88	0,90	481			1,33	
	38.13	0,84	0,86	481			1,21	
	46.13	0,80	0,82	480			1,10	
60,5	54.15	0,77	0,78	482			0,99	
60,4	Mean			481,5	479,5	86078,60	1,53	86080,13

August 9. P. M. Barometer 30,04 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
60,3	0.55.12	1,21						
	1. 3.11	1,16	1,18	479			2,29	
	11. 9	1,10	1,13	477			2,09	
	19. 8	1,06	1,08	479			1,91	
	27. 8	1,01	1,03	480			1,74	
	35. 7	0,98	0,99	479			1,61	
	43. 7	0,93	0,95	480			1,48	
	51. 7	0,90	0,91	480			1,36	
	59. 7	0,86	0,88	480			1,27	
	2. 7. 7	0,82	0,84	480			1,16	
60,7	15. 7	0,79	0,80	480			1,05	
60,5	Mean			479,4	477,4	86077,03	1,60	86078,63

August 10, A. M. PORTSOY.—1st. Series.

Clock gaining 37',63. Barometer 30,10 inches.

Tem	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
58,7	7.30.24	1,20						
	38.22	1,16	1,18	478			2,29	
	46.20	1,10	1,13	478			2,09	
	54.19	1,06	1,08	479			1,91	
	8. 2.19	1,01	1,03	480			1,74	
	10.18	0,96	0,98	479			1,57	
	18.17	0,93	0,94	479			1,45	
	26.17	0,89	0,91	480			1,36	
	34.16	0,85	0,87	479			1,24	
	42.15	0,82	0,83	479			1,13	
59,0	50.15	0,80	0,81	480			1,08	
58,8	Mean			479,1	477,1	86076,80	1,59	86078,39

August 10, P. M. Barometer 30,16 inches.

Tem	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
59,8	1.26.11	1,18						
	34. 8	1,13	1,15	477			2,17	
	42. 6	1,08	1,10	478			1,98	
	50. 4	1,04	1,06	478			1,84	
	58. 2	0,99	1,01	478			1,67	
	2. 6. 0	0,95	0,97	478			1,54	
	13.58	0,91	0,93	478			1,42	
	22.56	0,87	0,89	478			1,30	
	30.56	0,84	0,85	480			1,18	
	38.54	0,81	0,82	478			1,10	
60,8	45.52	0,79	0,79	478			1,03	
60,3	Mean			478,1	476,1	86076,04	1,52	86077,56

August 11. A. M. PORTSOY.—1st Series.

Clock gaining 37s,63. Barometer 30,28 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours
°	h. m. s.	°	°				s.	
56,3	7.35.17	1,20						
	43.15	1,14	1,17	478			2,24	
	51.14	1,10	1,12	479			2,06	
	59.13	1,04	1,07	479			1,88	
	8. 7.12	1,01	1,02	479			1,71	
	15.11	0,96	0,98	479			1,57	
	23.10	0,92	0,94	479			1,45	
	31.10	0,89	0,90	480			1,33	
	39. 9	0,85	0,87	479			1,24	
	47. 9	0,81	0,83	480			1,13	
57,0	55. 9	0,78	0,79	480			1,02	
56.6	Mean			479,2	477,2	86076,88	1,56	86078,44

August 11, P. M. Barometer 30,27 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours
59,5	1.38.11	1,18						
	46. 9	1,13	1,15	478			2,17	
	54. 6	1,08	1,10	477			1,98	
	2. 2. 4	1,04	1,06	478			1,84	
	10. 1	1,00	1,02	477			1,77	
	18.59	0,96	0,98	478			1,57	
	26.57	0,91	0,93	478			1,42	
	34.55	0,87	0,89	478			1,30	
	42.53	0,83	0,85	478			1,18	
	50.51	0,80	0,82	478			1,10	
60,5	58.49	0,78	0,79	478			1,03	
60,0	Mean			477,8	475.8	86075,81	1,53	86077,34

August 12, A. M. Portsoy.—1st Series.

Clock gaining $37^s,63$ Barometer 30,26 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
58,6	7.31.30	1,16	1,13	477			2,09	
	39.27	1,11	1,08	477			1,91	
	47.24	1,06	1,03	477			1,74	
	55.21	1,01	0,99	477			1,60	
	8. 3.18	0,97	0,95	478			1,48	
	11.16	0,94	0,92	477			1,39	
	19.13	0,90	0,88	479			1,27	
	27.12	0,86	0,84	477			1,16	
	35. 9	0,82	0,80	478			1,05	
	43. 7	0,79	0,77	478			0,97	
	51. 5	0,76	0,74	477			0,89	
59,8	59. 2	0,73						
59,2	Mean			477,4	475,4	86075,51	1,41	86076,92

August 12, P. M. Barometer 30,27 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
61,0	1. 9.25	1,18	1,15	476			2,17	
	17.21	1,13	1,11	476			2,02	
	25.17	1,08	1,06	476			1,84	
	33.13	1,03	1,01	477			1,67	
	41.10	1,00	0,97	476			1,54	
	49. 6	0,95	0,93	477			1,42	
	57. 3	0,91	0,89	477			1,30	
	2. 5. 0	0,87	0,85	478			1,18	
	12.58	0,84	0,82	476			1,10	
	20.54	0,81	0,79	478			1,02	
61,3	28.52	0,78						
61,1	Mean			476,7	474,7	86074,98	1,53	86076,51

August 13, P. M. PORTSOY.—2d Series.

Clock gaining 42s,18 in a mean solar day. Barometer 30,25 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
61,5	1.10.17	1,21						
	18.13	1,16	1,18	476			2,28	
	26. 9	1,10	1,13	476			2,10	
	34. 6	1,06	1,08	477			1,91	
	42. 2	1,01	1,03	476			1,74	
	49.58	0,97	0,99	476			1,61	
	57.55	0,93	0,95	477			1,48	
	2. 5.52	0,90	0,91	477			1,35	
	13.48	0,86	0,88	476			1,27	
	21.46	0,82	0,84	478			1,16	
62,3	29.43	0,79	0,80	477			1,05	
61,9	Mean			476,6	474,6	86079,44	1,60	86081,04

August 14, A. M. Portsoy.—2d Series.

Clock gaining $42^{s},18$. Barometer 30,25 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
60,1	7.30.40	1,21	1,18	476			2,28	
	38.36	1,16	1,13	476			2,09	
	46.32	1,11	1,08	476			1,91	
	54.28	1,05	1,03	477			1,74	
	8. 2.25	1,01	0,99	476			1,61	
	10.21	0,98	0,96	477			1,51	
	18.18	0,94	0,92	477			1,39	
	26.15	0,90	0,88	477			1,27	
	34.12	0,86	0,84	477			1,16	
	42. 9	0,83	0,81	478			1,08	
60,5	50. 7	0,79						
60,3	Mean			476,7	474,7	86079,51	1,60	86081,11
August 14, P. M.						Barometer 30,27 inches.		
62,2	1.15.59	1,31	1,27	474			2,64	
	23.53	1,23	1,20	474			2,35	
	31.47	1,18	1,15	475			2,17	
	39.42	1,12	1,11	475			2,02	
	47.37	1,10	1,07	475			1,88	
	55.32	1,05	1,03	476			1,74	
	2. 3.28	1,01	0,98	475			1,57	
	11.23	0,96	0,93	476			1,42	
	19.19	0,91	0,89	475			1,30	
	27.14	0,87	0,85	477			1,19	
62,7	35.11	0,83						
62,4	Mean			475,2	473,2	86078,36	1,83	86080,19

August 15, A. M. PORTSOY.—2d Series.

Clock gaining $42^s,18$. Barometer 30,25 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
59,9	7.16.40	1,29	1,26	475			2,60	
	24.35	1,23	1,20	476			2,36	
	32.31	1,18	1,15	475			2,17	
	40.26	1,13	1,10	476			1,98	
	48.22	1,08	1,05	476			1,81	
	56.18	1,03	1,01	476			1,67	
	8. 4.14	0,99	0,97	477			1,54	
	12.11	0,96	0,93	476			1,42	
	20. 7	0,91	0,89	477			1,30	
	28. 4	0,87	0,85	477			1,18	
60,3	36. 1	0,83						
60,1	Mean			476,1	474,1	86079,05	1,80	86080,85

August 15, P. M. Barometer 30,25 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
61,4	1.11. 5	1,21	1,18	475			2,28	
	19. 0	1,16	1,13	474			2,09	
	26.54	1,11	1,09	476			1,95	
	34.50	1,07	1,04	474			1,78	
	42.44	1,02	1,00	476			1,64	
	50.40	0,98	0,96	476			1,51	
	58.36	0,94	0,92	475			1,39	
	2. 6.31	0,90	0,88	476			1,27	
	14.27	0,87	0,85	476			1,18	
	22.23	0,84	0,81	476			1,08	
61,9	30.19	0,79						
61,6	Mean			475,4	473,4	86078,51	1,62	86080,13

August 16, A. M. PORTSOY.—2d Series.

Clock gaining 42^s,18. Barometer 30,18 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
58,0	7.26.39	1,18	1,15	476			2,16	
	34.35	1,12	1,10	476			1,98	
	42.31	1,08	1,06	477			1,84	
	50.28	1,05	1,02	476			1,70	
	58.24	1,00	0,98	478			1,57	
	8. 6.22	0,96	0,93	477			1,42	
	14.19	0,91	0,89	477			1,30	
	22.16	0,88	0,86	476			1,21	
	30.12	0,85	0,83	478			1,13	
	38.10	0,81	0,79	478			1,02	
58,8	46. 8	0,78						
58,4	Mean			476,9	474,9	86079,66	1,53	86081,19

August 16, P. M.

Barometer 30,17 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
60,5	1. 5.32	1,21	1,18	474			2,28	
	13.26	1,15	1,13	476			2,09	
	21.22	1,11	1,08	475			1,91	
	29.17	1,06	1,04	475			1,77	
	37.12	1,02	0,99	476			1,60	
	45. 8	0,97	0,94	475			1,45	
	53. 3	0,92	0,90	476			1,33	
	2. 0.59	0,89	0,87	476			1,24	
	8.55	0,85	0,83	476			1,13	
	16.51	0,82	0,80	477			1,05	
61,3	24.48	0,79						
60,9	Mean			475,6	473,6	86078,67	1,59	86080,26

August 17, A. M. PORTSOY.—2d Series.

Clock gaining 42^s,18. Barometer 30,15 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
59,5	7.18.34	1,27						
	26.29	1,22	1,24	475			2,53	
	34.24	1,17	1,19	475			2,32	
	42.19	1,12	1,14	475			2,13	
	50.15	1,07	1,09	476			1,95	
	58.11	1,02	1,04	476			1,77	
	8. 6. 7	0,99	1,00	476			1,64	
	14. 3	0,95	0,97	476			1,54	
	21.59	0,91	0,93	476			1,42	
	29.55	0,88	0,89	476			1,30	
60,2	37.52	0,84	0,86	477			1,21	
59,8	Mean			475,8	473,8	86078,82	1,78	86080,60

August 17, P. M.

Barometer 30,16 inches.

61,0	1.28.27	1,30						
	36.21	1,23	1,26	474			2,60	
	44.16	1,18	1,20	475			2,36	
	52.10	1,13	1,15	474			2,17	
	2. 0. 4	1,09	1,11	474			2,02	
	8. 0	1,04	1,06	476			1,84	
	15.55	1,00	1,02	475			1,71	
	23.51	0,95	0,97	476			1,54	
	31.46	0,92	0,93	475			1,42	
	39.42	0,88	0,90	476			1,33	
61,5	47.38	0,84	0,86	476			1,21	
61,2	Mean			475,1	473,1	86078,29	1,82	86080,11

August 18, A. M. Portsoy.—2d Series.

Clock gaining $42^s,18$ Barometer 30,14 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
58,4	7.32.46	1,20						
	40.41	1,16	1,18	475			2,28	
	48.37	1,10	1,13	476			2,09	
	56.33	1,06	1,08	476			1,91	
	8. 4.29	1,01	1,03	476			1,74	
	12.25	0,98	0,99	476			1,60	
	20.21	0,93	0,95	476			1,48	
	28.18	0,89	0,91	477			1,36	
	36.15	0,85	0,87	477			1,24	
	44.12	0,81	0,83	477			1,13	
58,5	52. 9	0,78	0,79	477			1,02	
58,4	Mean			476,3	474,3	86079,20	1,59	86080,79

August 18, P. M. Barometer 30,14 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
59,7	1. 0.54	1,21						
	8,49	1,15	1,18	475			2,28	
	16.44	1,10	1,12	475			2,06	
	24.39	1,06	1,08	475			1,92	
	32.34	1,01	1,03	475			1,74	
	40.29	0,97	0,99	475			1,60	
	48.25	0,93	0,95	476			1,48	
	56.21	0,89	0,91	476			1,36	
	2. 4.17	0,85	0,87	476			1,24	
	12.13	0,82	0,83	476			1,13	
60,7	20. 9	0,79	0,80	476			1,05	
60,2	Mean			475,5	473,5	86078,59	1,59	86080,18

August 19, A. M. PORTSOY.—2d Series.

Clock gaining $42^s,18$. Barometer 30,1 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°					
57,3	7.38.35	1,20						
	46.30	1,14	1,17	475			2,24	
	54.26	1,11	1,12	476			2,06	
	8. 2.22	1,05	1,08	476			1,92	
	10.18	1,01	1,03	476			1,74	
	18.15	0,98	0,99	477			1,60	
	26.11	0,94	0,96	476			1,51	
	34. 8	0,89	0,91	477			1,36	
	42. 5	0,85	0,87	477			1,24	
	50. 2	0,81	0,83	477			1,13	
57.5	58.59	0,78	0,79	477			1,02	
57,4	Mean			476,4	474,4	86079,27	1,58	86080,85

August 31, A. M. at LEITH FORT.—1st. Series

Clock gaining 26^s,85 in a mean solar day. Barometer 29,95 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
56,5	7.29. 9	1,10						
	37.21	1,06	1,08	492			1,91	
	45.35	1,02	1,04	494			1,77	
	54.49	0,97	0,99	494			1,61	
	8. 2. 2	0,93	0,95	493			1,48	
	10.17	0,88	0,90	495			1,33	
	18.32	0,85	0,86	495			1,21	
	26.46	0,82	0,83	494			1,13	
	35. 0	0,78	0,80	494			1,05	
	43.16	0,75	0,76	496			0,94	
5,67	51.30	0,73	0,74	494			0,89	
56,6	Mean			494,1	492,1	86077,01	1,33	86078,34

August 31, P. M. Barometer 29,85 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
58,6	1.33.24	1,17						
	41.36	1,12	1,14	492			2,13	
	49.48	1,07	1,09	492			1,95	
	58. 0	1,03	1,05	492			1,80	
	2. 6.13	0,98	1,00	493			1,64	
	14.26	0,94	0,96	493			1,51	
	22 38	0,89	0,91	492			1,36	
	30.52	0,86	0,87	494			1,24	
	39 5	0,83	0,84	493			1,16	
	47.18	0,80	0,81	493			1,08	
59,2	55.31	0,77	0,78	493			1,00	
58,9	Mean			492,7	490,7	86076,02	1,48	86077,50

September 1, A. M. LEITH FORT.—1st Series.

Clock gaining 26ʹ,85. Barometer 29,55 inches.

Temp.	Time of coincidence	Arc of vibration	Mean Arc.	Interval in seconds.	No of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
58,7	8. 3. 0	1,22						
	11. 9	1,17	1,19	489			2,32	
	19.18	1,12	1,14	489			2,13	
	27.28	1,07	1,09	490			1,95	
	35.39	1,03	1,05	491			1,80	
	43.49	0,98	1,00	490			1,64	
	52. 0	0,94	0,96	491			1,51	
	9. 0.12	0,90	0,92	492			1,39	
	8.22	0,87	0,88	490			1,27	
	16.34	0,83	0,85	492			1,18	
58,8	24.45	0,79	0,81	491			1,07	
58,7	Mean			490,5	488,5	86074,45	1,63	86076,08

September 1, P. M. Barometer 29,49 inches.

Temp.	Time of coincidence	Arc of vibration	Mean Arc.	Interval in seconds.	No of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
59,7	1.50.37	1,12						
	58.46	1,07	1,09	489			1,95	
	2. 6.57	1,02	1,04	491			1,77	
	15. 7	0,98	1,00	490			1,64	
	24.16	0,93	0,95	489			1,48	
	31.27	0,89	0,91	491			1,36	
	39.37	0,85	0,87	490			1,24	
	47.48	0,82	0,83	491			1,13	
	55.59	0,78	0,80	491			1,05	
	3. 4. 9	0,76	0,77	490			1,97	
60,5	12.21	0,73	0,74	492			1,89	
60,1	Mean			490,4	488,4	86074,37	1,35	86075,72

September 2, A. M. LEITH FORT.—1st Series.

Clock gaining 26^s,85. Barometer 29,58 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
58,0	8.19.41	1,12	1,09	489			1,95	
	27.50	1,07	1,04	489			1,77	
	35.59	1,02	0,99	489			1,61	
	44. 8	0,97	0,95	490			1,48	
	52.18	0,93	0,90	490			1,33	
	9. 0.28	0,88	0,86	489			1,21	
	8.37	0,85	0,83	490			1,13	
	16.47	0,82	0,80	490			1,05	
	24.57	0,78	0,76	490			0,94	
	33. 7	0,75	0,74	490			0,89	
58,7	41.17	0,73						
58,4	Mean			489,6	487,6	86073,80	1,34	86075,14

September 2, P. M. Barometer 29,68 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
59,8	1.15.32	1,08	1,05	488			1,80	
	23.40	1,03	1,00	488			1,64	
	31.48	0,98	0,96	489			1,51	
	39.57	0,94	0,92	488			1,39	
	48. 5	0,91	0,89	490			1,30	
	56.15	0,87	0,85	489			1,18	
	2. 4.24	0,83	0,81	489			1,08	
	12.33	0,80	0,78	489			1,00	
	20.42	0,76	0,74	489			0,90	
	28.51	0,73	0,71	490			0,82	
60,0	37. 1	0,70						
59,9	Mean			488,9	486,9	86073,29	1,26	86074,55

September 3, A. M. LEITH FORT.—1st Series.

Clock gaining 26^s,85. Barometer 29,95 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
56,9	7.49.55	1,07						
	58. 4	1,03	1,05	489			1,80	
	8. 6.13	0,98	1,00	489			1,64	
	14.22	0,94	0,96	489			1,51	
	22.32	0,91	0,92	490			1,39	
	30.42	0,87	0,89	490			1,30	
	38.52	0,83	0,85	490			1,18	
	47. 2	0,79	0,81	490			1,08	
	55.13	0,76	0,77	491			0,97	
	9. 3.22	0,73	0,74	489			0,90	
57,9	11.32	0,70	0,71	490			0,82	
57,4	Mean			489,7	487,7	86073,87	1,26	86075,13

September 3. P. M. Barometer 29,97 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
59,5	1. 6. 6	1,18						
	14.12	1,13	1,15	486			2,17	
	22.19	1,06	1,09	487			1,95	
	30.28	1,03	1,04	489			1,77	
	38.35	0,98	1,00	487			1,64	
	46.43	0,94	0,96	488			1,51	
	54.52	0,90	0,92	489			1,39	
	2. 3. 0	0,86	0,88	488			1,27	
	11. 8	0,83	0,84	488			1,15	
	19.17	0,79	0,81	489			1,08	
59,9	27.26	0,76	0,77	489			0,97	
59,7	Mean			488	486	86072,64	1,49	86074,13

September 4, A. M. Leith Fort.—1st. Series.

Clock gaining 26s,85. Barometer 29,78 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibratons in 24 hours.
°	h. m. s.	°	°				s.	
59,3	7.55.48	1,18	1,15	486			2,17	
	8. 3.54	1,13	1,10	488			1,98	
	12. 2	1,08	1,05	488			1,80	
	20.10	1,02	1,00	488			1,64	
	28.18	0,98	0,95	488			1,48	
	36.26	0,93	0,91	488			1,36	
	44.34	0,90	0,88	488			1,27	
	52.42	0,87	0,85	489			1,18	
	9. 0.51	0,83	0,81	488			1,08	
	8.59	0,79	0,77	489			0,97	
59,8	17. 8	0,76						
59,5	Mean			488	486	86072,64	1,49	86074,13

September 4, P. M. Barometer 29,76 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibratons in 24 hours.
61,6	1.21.40	1,17	1,14	486			2,13	
	29.46	1,12	1,09	486			1,95	
	37.52	1,06	1,04	486			1,77	
	45.58	1,02	1,00	487			1,64	
	54. 5	0,98	0,95	487			1,48	
	2. 2.12	0,93	0,91	486			1,36	
	10.18	0,90	0,88	488			1,27	
	18.26	0,87	0,85	487			1,18	
	26.33	0,83	0,81	487			1,08	
	34.40	0,79	0,77	487			0,97	
62,2	42.47	0,76						
61,9	Mean			486,7	484,7	86071,68	1,48	86073,16

September 5, A. M. LEITH FORT.—1st Series.

Clock gaining $26^s,85$. Barometer 29,85 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations. in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
60,0	7.44. 8	1,19	1,16	484			2,21	
	52.12	1,14	1,11	486			2,02	
	8. 0.18	1,09	1,06	485			1,84	
	8.23	1,04	1,02	485			1,71	
	16.28	1,00	0,98	486			1,57	
	24.34	0,96	0,94	486			1,45	
	32.40	0,93	0,91	486			1,36	
	40.46	0,89	0,86	486			1,21	
	48.52	0,84	0,82	486			1,10	
	56.58	0,81	0,80	486			1,05	
60,6	9. 5. 4	0,79						
60,3	Mean			485,6	483,6	86070,88	1,55	86072,43
September 5, P. M.				Barometer 29,83 inches.				
62,0	0.58.30	1,14	1,11	485			2,02	
	1. 6.35	1,09	1,07	483			1,88	
	14.38	1,05	1,02	485			1,71	
	22.43	0,99	0,97	484			1,54	
	30.47	0,95	0,93	485			1,42	
	38.52	0,92	0,90	484			1,32	
	46.56	0,88	0,87	485			1,24	
	55. 1	0,86	0,83	485			1,13	
	2. 3. 6	0,81	0,79	484			1,02	
	11.10	0,78	0,76	486			0,94	
62,3	19.16	0,75						
62,1	Mean			484,6	482,6	86070,15	1,42	86071,57

September 6, A. M. LEITH FORT.—1st Series.

Clock gaining 26ˢ,85. Barometer 29,6 inches.

Tem	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
59,7	7.49.27	1,13	1,10	483			1,98	
	57.30	1,08	1,05	483			1,80	
	8. 5.33	1,03	1,00	483			1,64	
	13.36	0,98	0,96	484			1,51	
	21.40	0,94	0,92	483			1,38	
	29.43	0,90	0,88	483			1,27	
	37.46	0,86	0,84	484			1,15	
	45.50	0,83	0,81	484			1,07	
	53.54	0,79	0,77	485			0,97	
	9. 1.59	0,75	0,73	485			0,87	
60,2	10. 4	0,72						
59,9	Mean			483,7	481,7	86069,49	1,36	86070,85

September 6, P. M. Barometer 29,62 inches.

Tem	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
61,4	1.11.44	1,18	1,15	481			2,17	
	19.45	1,13	1,10	482			1,98	
	27.47	1,08	1,05	483			1,80	
	35.50	1,03	1,00	482			1,64	
	43.52	0,98	0,96	484			1,51	
	51.56	0,95	0,93	483			1,42	
	59.59	0,91	0,89	483			1,30	
	2. 8. 2	0,87	0,85	483			1,18	
	16. 5	0,83	0,81	484			1,07	
	24. 9	0,81	0,78	483			1,00	
61,3	32.12	0,78						
61,4	Mean			482,8	480,8	86068,82	1,51	86070,33

September 9, A. M. LEITH FORT.—2d Series.

Clock gaining $34^s,1$ in a mean solar day. Bar. 29,9 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
54,2	7.55.58	1,16						
	8. 3.59	1,12	1,14	481			2,13	
	12. 1	1,08	1,10	482			1,98	
	20. 3	1,04	1,06	482			1,84	
	28. 5	1,01	1,02	482			1,70	
	36. 7	0,97	0,99	482			1,60	
	44.10	0,93	0,95	483			1,48	
	52.12	0,90	0,91	482			1,36	
	9. 0.15	0,88	0,89	483			1,30	
	8.17	0,84	0,86	482			1,21	
54,3	16.19	0,81	0,82	482			1,10	
54,2	Mean			482,1	480,1	86075,53	1,57	86077,10
	September 9, P. M.				Barometer 29,95 inches.			
55,5	1.13.37	1,19						
	21.38	1,14	1,16	481			2,21	
	29.38	1,10	1,12	480			2,06	
	37.40	1,03	1,06	482			1,84	
	45.41	1,00	1,01	481			1,67	
	53.42	0,96	0,98	481			1,57	
	2. 1.44	0,92	0,94	482			1,45	
	9.45	0,88	0,90	481			1,33	
	17.47	0,85	0,86	482			1,21	
	25.49	0,82	0,83	482			1,13	
55,7	33.52	0,79	0,81	483			1,08	
55,6	Mean			481,5	479,5	86075,07	1,56	86076,63

September 10, A. M. Leith Fort.—2d Series.

Clock gaining, 34',10. Barometer 29,94 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°	°			s.	
52,1	7.59.12	1,15	1,12	482			2,06	
	8. 7.14	1,10	1,08	482			1,91	
	15.16	1,06	1,04	483			1,78	
	23.19	1,02	1,00	482			1,64	
	31.21	0,98	0,96	483			1,51	
	39.24	0,94	0,92	483			1,39	
	47.27	0,90	0,88	483			1,27	
	55.30	0,87	0,85	483			1,18	
	9. 3.33	0,84	0,82	483			1,11	
	11.36	0,80	0,77	483			0,97	
52,8	19.39	0,77						
52,4	Mean			482,7	480,7	86075,97	1,48	86077,45

September 10, P. M.

Barometer 29,91 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
54,2	1. 8.54	1,14	1,12	482			2,06	
	16.56	1,10	1,07	481			1,88	
	24.57	1,04	1,02	482			1,71	
	32.59	1,00	0,98	482			1,57	
	41. 1	0,96	0,94	482			1,45	
	49. 3	0,93	0,91	481			1,36	
	57. 4	0,89	0,86	482			1 21	
	2. 5. 6	0,84	0,82	483			1,10	
	13. 9	0,81	0,79	483			1,02	
	21.12	0,78	0,76	482			0,94	
54,3	29.14	0,74						
54,2	Mean			482	480	86075,45	1,53	86076,98

September 11, A. M. LEITH FORT.—2d Series.

Clock gaining 34ˢ,10. Barometer 29,92 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
51,3	7.58.14	1,17	1,15	481			2,16	
	8. 6.15	1,13	1,10	482			1,98	
	14.17	1,08	1,06	482			1,84	
	22.19	1,05	1,03	482			1,74	
	30.21	1,01	0,99	483			1,60	
	38.24	0,98	0,96	482			1,51	
	46.26	0,94	0,91	482			1,36	
	54.28	0,89	0,87	483			1,24	
	9. 2.31	0,86	0,84	482			1,16	
	10.33	0,82	0,80	483			1,05	
51,8	18.36	0,79						
51,5	Mean			482,2	480,2	86075,60	1,56	86077,16

September 11, P. M. Barometer 29,95 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
53,2	1.12. 9	1,14	1,11	481			2,02	
	20.10	1,09	1,06	481			1,84	
	28.11	1,04	1,01	482			1,67	
	36.13	0,99	0,97	481			1,54	
	44.14	0,95	0,93	482			1,42	
	52.16	0,91	0,89	482			1,30	
	2. 0.18	0,88	0,86	483			1,21	
	8.21	0,84	0,82	482			1,10	
	16.23	0,81	0,79	482			1,02	
	24.25	0,78	0,76	482			0,94	
53,5	32.27	0,74						
53,3	Mean			481,8	479,8	86075,30	1,41	86076,71

September 12, A. M. Leith Fort.—2d. Series.

Clock gaining 34',10. Barometer 30,14 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
52,8	8.16.19	1,17	1,14	481			2,13	
	24.20	1,12	1,09	481			1,95	
	32.21	1,07	1,04	480			1,77	
	40.21	1,02	1,00	483			1,64	
	48.23	0,98	0,96	481			1,51	
	56.24	0,94	0,92	482			1,38	
	9. 4.26	0,91	0,89	482			1,30	
	12.28	0,87	0,85	482			1,18	
	20.30	0,83	0,81	483			1,0[illegible]	
	28.33	0,80	0,78	481			1,00	
53,4	36.34	0,77						
53,1	Mean			481,6	479,6	86075,15	1,49	86076,64
September 12, P. M.					**Barometer 30,14 inches.**			
53,9	0. 8.28	1,16	1,13	480			2,09	
	16.28	1,11	1,08	481			1,92	
	24.29	1,06	1,03	480			1,74	
	32.29	1,01	0,99	481			1,60	
	40.30	0,97	0,95	481			1,48	
	48.31	0,93	0,90	482			1,33	
	56.33	0,88	0,86	481			1,21	
	1. 4.34	0,85	0,83	481			1,13	
	12.35	0,82	0,80	482			1,05	
	20.37	0,79	0,77	482			0,97	
54,5	28.39	0,76						
54,2	Mean			481,1	479,1	86074,77	1,45	86076,22

September 13, A. M. LEITH FORT.—2d. Series.

Clock gaining 34",10. Barometer 30,28 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
53,6	8.37.37	1,14						
	45.36	1,09	1,11	479			2,02	
	53.36	1,04	1,06	480			1,84	
	9. 1.37	1,00	1,02	481			1,71	
	9.38	0,96	0,98	481			1,57	
	17.39	0,92	0,94	481			1,45	
	25.40	0,88	0,90	481			1,33	
	33.41	0,84	0,86	481			1,21	
	41.42	0,81	0,82	481			1,10	
	49.42	0,78	0,79	481			1,02	
54,4	57.45	0,75	0,76	483			0,94	
54,0	Mean			480,9	478,9	86074,63	1,42	86076,05

September 13, P. M. Barometer 30,24 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
° 55,6	1. 7.18	1,12						
	15.17	1,07	1,09	479			1,95	
	23.16	1,02	1,04	479			1,77	
	31,16	0,98	1,00	480			1,64	
	39,16	0,94	0,96	480			1,51	
	47,17	0,91	0,92	481			1,39	
	55.17	0,87	0,89	480			1,30	
	2. 3.17	0,83	0,85	480			1,18	
	11.18	0,80	0,81	481			1,08	
	19.18	0,77	0,78	480			1,00	
56,3	27.19	0,74	0,75	481			0,92	
55,9	Mean			480,1	478,1	86074,03	1,37	86075,40

September 14, A. M. Leith Fort.—2nd Series.

Clock gaining 34ˢ,10. Barometer 29,89 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
56,2	8.16.19	1,09	1,06	480			2,13	
	24.19	1,04	1,02	479			1,95	
	32.18	1,00	0,98	480			1,80	
	40.18	0,97	0,95	480			1,64	
	48.18	0,93	0,91	480			1,51	
	56.18	0,89	0,87	480			1,38	
	9. 4.18	0,85	0,83	480			1,27	
	12.18	0,82	0,80	481			1,18	
	20.19	0,78	0,77	480			1,10	
	28.19	0,76	0,74	481			0,99	
56,6	36.20	0,73						
56,4	Mean			480,1	478,1	86074,03	1,32	86075,35
September 14, P. M.						Barometer 29,85 inches.		
57,1	1.21.53	1,16	1,14	478			2,13	
	29.51	1,12	1,09	479			1,95	
	37.50	1,07	1,05	478			1,80	
	45.48	1,03	1,00	480			1,64	
	53.48	0,98	0,96	479			1,51	
	2. 1.47	0,94	0,92	479			1,38	
	9.46	0,90	0,88	479			1,27	
	17.45	0,87	0,85	480			1,18	
	25.45	0,84	0,82	480			1,10	
	33.45	0,80	0,78	480			0,99	
57,2	41.45	0,77						
57,1	Mean			479,2	477,2	86073,36	1,50	86074,86

October 3, A. M. at CLIFTON.

Clock losing 10',60 in a mean solar day. Barometer 29,22 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
57,2	7.32.46	1,23						
	41.34	1,17	1,20	528			2,36	
	50.23	1,12	1,14	529			2,13	
	59.10	1,07	1,09	527			1,95	
	8. 7.59	1,02	1,04	529			1,77	
	16.48	0,98	1,00	529			1,64	
	25.38	0,93	0,95	530			1,48	
	34.27	0,88	0,90	529			1,33	
	43.17	0,84	0,86	530			1,21	
	52. 7	0,82	0,83	530			1,13	
57,7	9. 0.58	0,78	0,80	531			1,05	
57,4	Mean			529,2	527,2	86062,91	1,61	86064,52
	October 3, P. M.				Barometer, 29,20 inches.			
58,2	1.56.23	1,28						
	2. 5. 9	1,23	1,25	526			2,57	
	13.57	1,17	1,20	528			2,36	
	22.44	1,12	1,14	527			2,13	
	31.31	1,07	1,09	527			1,95	
	40.19	1,02	1,04	528			1,77	
	49. 7	0,97	0,99	528			1,61	
	57.56	0,93	0,95	529			1,48	
	3. 6.45	0,89	0,91	529			1,36	
	15.34	0,84	0,86	529			1,21	
58,3	24.23	0,81	0,82	529			1,10	
58,2	Mean			528	526	86062,17	1,75	86063,92

October 4, A. M. CLIFTON.

Clock losing 10',60. Barometer 29,18 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
57,1	9.44. 8	1,23						
	52.57	1,17	1,20	529			2,36	
	10. 1.45	1,12	1,15	528			2,17	
	10.33	1,06	1,09	528			1,95	
	19.22	1,02	1,04	529			1,77	
	28.11	0,97	0,99	529			1,61	
	37. 1	0,92	0,94	530			1,45	
	45.49	0,88	0,90	528			1,33	
	54.38	0,83	0,85	529			1,18	
	11. 3.29	0,79	0,81	531			1,08	
57,3	12.19	0,76	0,77	530			0,97	
57,2	Mean			529,1	527,1	86062,85	1,59	86064,44

October 4, P. M. Barometer 29,13 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
57,2	1. 6.12	1,24						
	15. 0	1,20	1,22	528			2,43	
	24.47	1,13	1,16	527			2,20	
	32.35	1,08	1,10	528			1,98	
	41.24	1,04	1,06	529			1,84	
	50.12	0,99	1,01	528			1,67	
	58.59	0,94	0,96	527			1,51	
	2. 7.48	0,89	0,91	529			1,36	
	16.37	0,85	0,87	529			1,24	
	25.27	0,82	0,83	530			1,13	
57,3	34.18	0,78	0,80	531			1,05	
57,2	Mean			528,6	526,6	86062,54	1,64	86064,18

October 5, A. M. Clifton.

Clock losing 10s,60. Barometer 29,10 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
54,8	7.57. 6	1,23	1,21	529			2,40	
	8. 6.55	1,18	1,15	530			2,17	
	14.45	1,12	1,09	530			1,95	
	23.35	1,07	1,04	529			1,77	
	32.24	1,02	0,99	531			1,61	
	41.15	0,97	0,95	531			1,48	
	50. 6	0,93	0.91	530			1,36	
	58.56	0,89	0,86	531			1,21	
	9. 7.47	0,84	0,82	531			1,10	
	16.38	0,81	0,79	532			1,02	
55,4	25.30	0,78						
55,1	Mean			530,4	528,4	86063,65	1,61	86065,26

October 5, P. M. Barometer 29,08 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
55,6	1.52.53	1,27	1,24	528			2,52	
	2. 1.41	1,22	1,20	529			2,36	
	10.30	1,18	1,15	529			2,17	
	19.19	1,13	1,10	529			1,98	
	28. 8	1,07	1,04	529			1,77	
	36.57	1,02	1,00	530			1,64	
	45.47	0,98	0,95	531			1,48	
	54.38	0.93	0,91	530			1,36	
	3. 3.28	0,89	0,87	529			1,24	
	12.17	0,86	0,84	532			1,15	
55,9	21. 9	0,82						
55,7	Mean			529,6	527,6	86063,16	1.77	86064,93

October 6, A. M. CLIFTON.

Clock losing 10ˢ,60 Barometer 29,01 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s,	°	°				s.	
53.2	7.52.54	1,31						
	8. 1.43	1,25	1,28	529			2,68	
	10.33	1,19	1,22	530			2,44	
	19.24	1,13	1,16	531			2,20	
	28.14	1,08	1,10	530			1,98	
	37. 5	1,03	1,05	531			1,80	
	45.56	0,98	1,00	531			1,64	
	54.47	0,93	0,95	531			1,48	
	9. 3.38	0,88	0,90	531			1,33	
	12.30	0,85	0,86	532			1,21	
53,6	21.23	0,82	0,83	533			1,13	
53,4	Mean			530,9	528,9	86063,96	1,79	86065,75

October 6, P. M. Barometer 29,10 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
53,9	1.55. 5	1,22						
	2. 3.54	1,16	1,19	529			2,32	
	12.45	1,11	1,13	531			2,09	
	21.34	1,06	1,08	529			1,91	
	30.24	1,01	1,03	530			1,74	
	39.14	0,97	0,99	530			1,60	
	48. 5	0,92	0,94	531			1,45	
	56.56	0,87	0,89	531			1,30	
	3. 5.46	0,83	0,85	530			1,18	
	14.36	0,79	0,81	530			1,08	
55,1	23.27	0,76	0,77	531			0,97	
54,5	Mean			530,2	528,2	86063,52	1,56	86065,08

October 7, A. M. CLIFTON.

Clock losing 10",60. Barometer 29,30 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
52,5	9.34.54	1,28						
	43.43	1,23	1,25	529			2,57	
	52.33	1,18	1,20	530			2,36	
	10. 1.22	1,13	1,15	529			2,17	
	10.12	1,07	1,10	530			1,98	
	19. 3	1,02	1,04	531			1,77	
	27.54	0,97	0,99	531			1,61	
	36.45	0,92	0,94	531			1,45	
	45 36	0,88	0,90	531			1,33	
	54.27	0,84	0,86	531			1,21	
53,3	11. 3.19	0,81	0,82	532			1,10	
52,9	Mean			530,5	528,5	86063,71	1,76	86065,47

October 7, P. M. Barometer 29,33 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
53,4	1.53.19	1,23						
	2. 2. 9	1,17	1,20	530			2,36	
	10.58	1,12	1,14	529			2,13	
	19.48	1,07	1,09	530			1,95	
	28.38	1,02	1,04	530			1,77	
	37.29	0,97	0,99	531			1,60	
	46.19	0,93	0,95	530			1,48	
	55.10	0,89	0,91	531			1,36	
	3. 4. 1	0,84	0,86	531			1,21	
	12.51	0,82	0,83	530			1,13	
54,1	21.43	0,78	0,80	532			1,05	
53,7	Mean			530,4	528,4	86063,65	1,60	86065,25

October 8, A. M. Clifton.

Clock losing 10",60. Barometer 29,52 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
51,9	7.54.51	1,24						
	8. 3.40	1,19	1,21	529			2,40	
	12.30	1,13	1,16	530			2,20	
	21.19	1,08	1,10	529			1,98	
	30. 8	1,03	1,05	529			1,81	
	39. 0	0,99	1,01	532			1,67	
	47.51	0,93	0,96	531			1,51	
	56.42	0,90	0,91	531			1,36	
	9. 5.53	0,87	0,88	531			1,27	
	14.24	0,83	0,85	531			1,18	
52,5	23.16	0,79	0,81	532			1,07	
52,2	Mean			530,5	528,5	86063,71	1,65	86065,36

October 8. P. M.

Barometer 29,57 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
52,7	2.24. 0	1,23						
	42.49	1,18	1,20	529			2,36	
	51.38	1,13	1,15	529			2,17	
	3. 0.27	1,07	1,10	529			1,98	
	9.17	1,02	1,04	530			1,77	
	18. 7	0,98	1,00	530			1,64	
	26.58	0,93	0,95	531			1,48	
	35.48	0,89	0,91	530			1,36	
	44.39	0,85	0,87	531			1,24	
	53.30	0,81	0,83	531			1,13	
53,2	4. 2.21	0,78	0,79	531			1,02	
52,9	Mean			530,1	528,1	86063,46	1,62	86065,08

October 21, P. M.—at ARBURY HILL.

Clock losing 6ˢ,2 in a mean solar day. Barometer 29,65 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
56,7	1.33.46	1,19						
	42,18	1,13	1,16	512			2,20	
	50,52	1,09	1,11	514			2,02	
	59.26	1,05	1,07	514			1,88	
	2. 8. 0	1,00	1,02	514			1,70	
	16.34	0,96	0,98	514			1,57	
	25. 8	0,92	0,94	514			1,45	
	33.43	0,88	0,90	515			1,33	
	42.17	0,84	0,86	514			1,21	
	50.52	0,81	0,82	515			1,10	
56,7	59.27	0,78	0,79	515			1,02	
56,7	Mean			514,1	512,1	86057,70	1,55	86059,25

October 22, A. M. Arbury Hill.

Clock losing 6s,2. Barometer 29,52 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours
°	h. m. s.	°	°				s.	
54,1	9.10.38	1,13						
	19.13	1,10	1,12	515			2,06	
	27.49	1,06	1,08	516			1,91	
	36,25	1,02	1,04	516			1,77	
	45. 1	0,97	0,99	516			1,61	
	53.37	0,93	0,95	516			1,48	
	10. 2.13	0,89	0,91	516			1,36	
	10.50	0,85	0,87	517			1,24	
	19.27	0,82	0,83	517			1,13	
	28. 4	0,78	0,80	517			1,05	
54,4	36.42	0,74	0,76	518			0,94	
54.2	Mean			516,4	514,4	86059,20	1,46	86060,66

October 22, P. M. Barometer 29,50 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours
54,4	1.52.46	1,14						
	2. 1.22	1,10	1,12	516			2,06	
	9.57	1,06	1,08	515			1,91	
	18.33	1,02	1,04	516			1,77	
	27.10	0,97	0,99	517			1,61	
	35.45	0,92	0,94	515			1,45	
	44.22	0,88	0,90	517			1,33	
	52.58	0,86	0,87	516			1,24	
	3. 1.35	0,82	0,84	517			1,15	
	10.12	0,78	0,80	517			1,05	
54,4	18.48	0,75	0,76	516			1,94	
54,4	Mean			516,2	514,2	86059,07	1,45	86060,52

October 23. ARBURY HILL.

Clock losing 6^s,20. Barometer 29,50 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
52,6	9. 8.44	1,21	1,19	516			2,32	
	17.20	1,17	1,14	516			2,13	
	25.56	1,12	1,09	516			1,95	
	34.32	1,06	1,04	516			1,77	
	43. 8	1,01	0,99	517			1,61	
	51.45	0,97	0,95	517			1,48	
	10. 0.22	0,93	0,91	518			1,36	
	9. 0	0,89	0,87	518			1,24	
	17.38	0,86	0,84	516			1,16	
	26.14	0,82	0,81	518			1,08	
53,1	34.52	0,80						
52,8	Mean			516,8	514,8	86059,46	1,61	86061,07
	October 23, P. M.				**Barometer 29,52 inches.**			
53,2	1.43.21	1,14	1,12	516			2,06	
	51.57	1,11	1,08	516			1,91	
	2. 0.33	1,05	1,03	516			1,74	
	9. 9	1,02	1,00	516			1,64	
	17.45	0,98	0,96	516			1,51	
	26.21	0,94	0,92	517			1,39	
	34.58	0,91	0,89	517			1,30	
	43.35	0,87	0,85	517			1,18	
	52.12	0,83	0,81	518			1,07	
	3. 0.50	0,80	0,78	518			1,00	
53,2	9.28	0,77						
53,2	Mean			516,7	514,7	86059,40	1,48	86060,88

October 24, A. M. ARBURY HILL.

Clock losing 6',20. Barometer 29,57 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
50,7	9. 9.14	1,17						
	17.51	1,12	1,14	517			2,13	
	26.28	1,07	1,09	517			1,95	
	35. 5	1,03	1,05	517			1,80	
	43.42	0,98	1,00	517			1,64	
	52.19	0,94	0,96	517			1,51	
	10. 0.57	0,90	0,92	518			1,39	
	9.35	0,86	0,88	518			1,27	
	18.12	0,82	0,84	517			1,16	
	27.51	0,78	0,80	519			1,05	
51,0	35.29	0,75	0,76	518			0,94	
50,8	Mean			517,5	515,5	86059,92	1,48	86061,40

October 24, P. M. Barometer 29,55 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
50,5	1.35. 5	1,22						
	43.41	1,17	1,19	516			2,32	
	52.17	1,12	1,14	516			2,13	
	2. 0.54	1,08	1,10	517			1,98	
	9.30	1,03	1,05	516			1,80	
	18. 7	0,98	1,00	517			1,64	
	26.44	0,94	0,96	517			1,51	
	35.22	0,90	0,92	518			1,39	
	44. 0	0,87	0,88	518			1,27	
	52.38	0,83	0,85	518			1,18	
50,8	3. 1. 16	0,79	0,81	518			1,07	
50,6	Mean			517,1	515,1	86059,65	1,63	86061,28

October 25, A. M. ARBURY HILL.

Clock losing 6',20. Barometer 29,56 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
50,7	9.19.37	1,18						
	28.13	1,12	1,15	516			2,17	
	36.50	1,08	1,10	517			1,98	
	45.26	1,03	1,05	516			1,81	
	54. 3	0,98	1,00	517			1,64	
	10. 2.42	0,93	1,95	519			1,48	
	11.19	0,89	0,91	517			1,36	
	19.56	0,84	0,86	517			1,21	
	28.34	0,82	0,83	518			1,13	
	37.14	0,79	0,80	520			1,05	
51,2	45.52	0,76	0,77	518			0,97	
50,9	Mean			517,5	515,5	86059,92	1,48	86061,40

October 25, P. M. Barometer 29,54 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
52,0	1.45.36	1,14						
	54.12	1,09	1,11	516			2,02	
	2. 2.49	1,03	1,06	517			1,84	
	11.25	1,00	1,01	516			1,67	
	20. 2	0,96	0,98	517			1,57	
	28.39	0,92	0,94	517			1,45	
	37.16	0,88	0,90	517			1,33	
	45.53	0,83	0,85	517			1,18	
	54.31	0,80	0,81	518			1,07	
	3. 3. 8	0,77	0,78	517			1,00	
52,6	11.46	0,73	0,75	518			0,92	
52,3	Mean			517	515	86059,59	1,41	86061,00

October 26, A. M. ARBURY HILL.

Clock losing 6^s,20. Barometer 29,55 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
51,9	9. 7.12	1,16	1,13	516			2,10	
	15.48	1,11	1,08	516			1,91	
	24.24	1,06	1,03	516			1,74	
	33. 0	1,01	0,98	516			1,57	
	41.36	0,96	0,94	516			1,45	
	50.12	0,92	0,90	517			1,33	
	58.49	0,88	0,85	517			1,18	
	10. 7.26	0,83	0,82	516			1,10	
	16. 2	0,81	0,79	518			1,02	
	24.40	0,78	0,75	516			0,92	
52,5	33.16	0,73						
52,2	Mean			516,4	514,4	86059,20	1,43	86060,63

October 26, P. M. Barometer 29,55 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
53,5	2. 8.18	1,15	1,13	515			2,10	
	16.53	1,11	1,08	515			1,91	
	25.28	1,06	1,03	515			1,74	
	34. 3	1,01	0,98	515			1,57	
	42.38	0,96	0,94	516			1,45	
	51.14	0,92	0,90	516			1,33	
	59.50	0,88	0,86	516			1,21	
	3. 8.26	0,85	0,83	516			1,13	
	17. 2	0,81	0,79	516			1,02	
	25.38	0,77	0,75	516			0,92	
53,9	34.14	0,73						
53,7	Mean	-		515,6	513,6	86058,68	1,44	86060,12

1819, March 8, A. M. *at Mr. Browne's house*, LONDON.

Clock gaining $1^s,75$ in a mean solar day. Barometer 30,10 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
49,8	10.40. 1	1,18	1,15	502			2,16	
	48.23	1,12	1,10	503			1,99	
	56.46	1,08	1,05	503			1,81	
	11. 5. 9	1,03	1,00	503			1,64	
	13.32	0,98	0,96	504			1,51	
	21.56	0,94	0,92	504			1,39	
	30.20	0,91	0,89	504			1,30	
	38.44	0,87	0,85	504			1,19	
	47. 8	0,83	0,81	504			1,07	
	55.32	0,80	0,78	505			1,00	
50,3	0. 3.57	0,77						
50,0	Mean			503,6	501,6	86058,61	1,51	86060,12

March 9, A. M. LONDON.

Clock gaining $1^s,85$. Barometer 30,10 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
49,8	10.35.36	1,14	1,11	503			2,02	
	43.59	1,09	1,07	503			1,88	
	52.22	1,05	1,03	503			1,74	
	11. 0.45	1,01	0,98	504			1,57	
	9. 9	0,96	0,94	505			1,45	
	17.34	0,92	0,90	503			1,33	
	25.57	0,88	0,86	504			1,21	
	34.21	0,84	0,82	504			1,11	
	42.45	0,81	0,79	504			1,02	
	51. 9	0,78	0,76	504			0,95	
50,5	59.33	0,74						
50,1	Mean			503,7	501,7	86058,78	1,43	86060,21

March 15, A. M. London.

Clock gaining 2s,24. Barometer 30,14 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
51,5	10.24.21	1,14						
	32.42	1,08	1,11	501			2,02	
	41.3	1,04	1,06	501			1,84	
	49.24	0,99	1,01	501			1,67	
	57.47	0,94	0,96	503			1,51	
	11. 6.9	0,91	0,92	502			1,38	
	14.31	0,88	0,89	502			1,30	
	22.53	0,84	0,86	502			1,21	
	31.16	0,81	0,82	503			1,10	
	39.38	0,78	0,79	502			1,02	
52,2	48.1	0,74	0,76	503			0,94	
51,8	Mean			502	500	86058,01	1,40	86059,41

March 16, A. M. London.

Clock gaining 2s,24. Barometer 30,0 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
52,2	10.20.42	1,18						
	29. 2	1,12	1,15	500			2,17	
	37.23	1,07	1,09	501			1,95	
	45.44	1,03	1,05	501			1,80	
	54. 5	0,98	1,00	501			1,64	
	11. 2.26	0,95	0,96	501			1,51	
	10.48	0,92	0,93	502			1,42	
	19. 9	0,88	0,90	501			1,33	
	27.30	0,84	0,86	501			1,21	
	35.52	0,81	0,82	502			1,10	
53,1	44.14	0,78	0,79	502			1,02	
52,7	Mean			501,2	499,2	86057,46	1,52	86058,98

March 17, A. M. LONDON.

Clock gaining 2^s,24. Barometer 30,10 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
53,2	10.24.19	1,17	1,15	500			2,17	
	32.39	1,13	1,10	501			1,98	
	41. 0	1,08	1,06	500			1,84	
	49.20	1,04	1,02	501			1,71	
	57.41	1,00	0,97	501			1,54	
	11. 6. 2	0,95	0,93	502			1,42	
	14.24	0,92	0,90	502			1,33	
	22.46	0,88	0,86	500			1,21	
	31. 6	0,84	0,82	502			1,10	
	39.28	0,81	0,79	502			1,02	
53,7	47.50	0,78						
53,5	Mean			501,1	499,1	86057,39	1,53	86058,92

March 18, A. M. LONDON.

Clock gaining 2^s,24. Barometer 30,21 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
52,5	10.39.58	1,16	1,13	501			2,09	
	48.19	1,11	1,08	500			1,91	
	56.39	1,06	1,04	501			1,77	
	11. 5. 0	1,02	0,99	501			1,60	
	13.21	0,97	0,95	501			1,48	
	21.42	0,93	0,91	501			1,36	
	30. 3	0,90	0,88	501			1,27	
	38.24	0,86	0,84	502			1,15	
	46.46	0,82	0,80	502			1,05	
	55. 8	0,78	0,77	502			0,97	
53,2	0. 3.30	0,76						
52,8	Mean			501,2	499,2	86057,46	1,47	86058,93

May 11, A. M. at SHANKLIN FARM.

Clock losing $9^s,4$ in a mean solar day. Barometer 30,17 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
60,5	9.27. 9	1,22	1,18	506			2,28	
	35.35	1,14	1,11	508			2,02	
	44. 3	1,09	1,06	508			1,84	
	52.31	1,04	1,01	508			1,68	
	10. 0.59	0,99	0,97	508			1,54	
	9.27	0,95	0,93	509			1,42	
	17.56	0,92	0,90	509			1,33	
	26.25	0,88	0,85	508			1,18	
	34.53	0,83	0,81	509			1,07	
	43.22	0,79	0,77	509			0,97	
61,3	51.51	0,76						
60,9	Mean			508,2	506,2	86050,61	1,53	86052,14

May 11, P. M. Barometer 30,16 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
61,6	0.22.53	1,20	1,17	506			2,24	
	31.19	1,14	1,11	507			2,02	
	39.46	1,08	1,06	508			1,84	
	48.14	1,04	1,01	507			1,68	
	56.41	0,99	0,96	507			1,51	
	1. 5. 8	0,94	0,92	508			1,38	
	13.36	0,91	0,89	507			1,30	
	22. 3	0,87	0,85	508			1,18	
	30.31	0,83	0,81	508			1,07	
	38.59	0,80	0,78	509			1,00	
62,1	47.28	0,76						
61,8	Mean			507,5	505,5	86050,21	1,52	86051,73

May 12, A. M. SHANKLIN FARM.

Clock losing $9^s,4$. Barometer 30,10 inches.

Temp.	Time of coincidence.	Arc of vibrations.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
	h. m. s.	°	°				s.	
60,6	9.17.32	1,18	1,15	507			2,17	
	25.59	1,13	1,10	508			1,98	
	34.27	1,08	1,05	507			1,81	
	42.54	1,03	1,00	507			1,64	
	51.21	0,98	0,96	508			1,51	
	59.49	0,94	0,92	508			1,39	
	10. 8.17	0,90	0,88	509			1,27	
	16.46	0,86	0,84	509			1,16	
	25.15	0,83	0,81	508			1,08	
	33.43	0,79	0,77	508			0,97	
61,4	42.11	0,76						
61,0	Mean			507,9	505,9	86050,46	1,50	86051,96

May 12, P. M.

Barometer 30,09 inches.

Temp.	Time of coincidence.	Arc of vibrations.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
61,2	0.16.43	1,21	1,18	507			2,28	
	25.10	1,16	1,13	507			2,09	
	33.37	1,11	1,08	507			1,91	
	42. 4	1,05	1,02	507			1,71	
	50.31	1,00	0,98	508			1,57	
	58.59	0,96	0,94	508			1,45	
	1. 7.27	0,93	0,90	508			1,32	
	15.55	0,88	0,86	508			1,21	
	24.23	0,84	0,82	508			1,10	
	32.51	0,81	0,79	508			1,02	
61,4	41.19	0,77						
61,3	Mean			507,6	505,6	86050,28	1,57	86051,85

May 13, A. M. Shanklin Farm.

Clock losing $9^s,4$. Barometer 30,08 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
6,08	9.12.17	1,16	1,14	506			2,13	
	20.43	1,12	1,09	507			1,95	
	29.10	1,06	1,04	507			1,77	
	37.37	1,02	0,99	508			1,60	
	46. 5	0,97	0,95	507			1,48	
	54.32	0,93	0,90	508			1,32	
	10. 3. 0	0,88	0,86	508			1,21	
	11.28	0,84	0,83	508			1,13	
	19.56	0,82	0,79	508			1,02	
	28.24	0,77	0,75	509			0,92	
60,9	36.53	0,73						
60,8	Mean			507,6	505,6	86050,28	1,45	86051,73

May 13, P. M.

Barometer 30,08 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
60,9	0.20.36	1,18	1,15	506			2,17	
	29. 2	1,13	1,10	507			1,99	
	37.29	1,08	1,05	507			1,81	
	45.56	1,03	1,00	507			1,64	
	54.23	0,98	0,96	507			1,51	
	1. 2.50	0,94	0,92	508			1,39	
	11.18	0,91	0,88	508			1,27	
	19.46	0,86	0,84	508			1,16	
	28.14	0,82	0,80	508			1,05	
	36.42	0,79	0,77	508			0,97	
61,1	45.10	0,76						
61,0	Mean			507,4	505,4	86050,14	1,50	86051,64

May 14, A. M. SHANKLIN FARM.

Clock losing 9s,4. Barometer 30,14 inches.

Temp	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
	h. m. s.	°	°				s.	
60,4	9.35.41	1,19	1,16	507			2,20	
	44. 8	1,14	1,11	507			2,01	
	52.35	1,08	1,05	508			1,81	
	10. 1. 3	1,03	1,01	508			1,67	
	9.31	0,99	0,97	508			1,54	
	17.59	0,95	0,93	509			1,42	
	26.28	0,92	0,90	508			1,33	
	34.56	0,88	0,86	509			1,21	
	43.25	0,84	0,82	509			1,10	
	51.54	0,80	0,78	509			1,00	
60,7	11. 0.23	0,76						
60,5	Mean			508,2	506,2	86050,61	1,53	86052,14

May 14, P. M.

Barometer 30,10 inches.

Temp	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
60,7	0.16.14	1,18	1,15	507			2,17	
	24.41	1,13	1,10	507			1,99	
	33. 8	1,08	1,05	508			1,81	
	41.36	1,03	1,00	508			1,64	
	50. 4	0,98	0,96	508			1,51	
	58.32	0,94	0,92	508			1,39	
	1. 7. 0	0,90	0,88	508			1,27	
	15.28	0,86	0,84	508			1,16	
	23.56	0,82	0,80	509			1,05	
	32.25	0,78	0,76	509			0,95	
60,9	40.54	0,75						
60,8	Mean			508	506	86050,48	1,49	86051,97

May 15, A. M. Shanklin Farm.

Clock losing $9^s,4$. Barometer 30,05 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
60,5	9.18.29	1,18	1,15	506			2,17	
	26.55	1,12	1,09	507			1,95	
	35.22	1,07	1,04	507			1,77	
	43.49	1,02	0,99	507			1,60	
	52.16	0,97	0,95	506			1,48	
	10. 0.42	0,93	0,91	507			1,36	
	9. 9	0,90	0,88	508			1,27	
	17.37	0,87	0,85	508			1,29	
	26. 5	0,83	0,81	508			1,18	
	34.33	0,79	0,77	508			0,97	
61,4	43. 1	0,76						
60,9	Mean			507,2	505,2	86049,94	1,50	86051,44

May 15, P. M. Barometer 30,05 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
61,3	0.31.38	1,17	1,14	506			2,13	
	40. 4	1,12	1,09	507			1,95	
	48.31	1,07	1,04	507			1,78	
	56.58	1,02	1,00	506			1,64	
	1. 5.24	0,98	0,95	507			1,48	
	13.51	0,93	0,91	507			1,36	
	22.18	0,89	0,87	508			1,24	
	31.46	0,85	0,83	507			1,13	
	39.13	0,82	0,80	507			1,05	
	47.40	0,78	0,76	508			0,95	
61,4	56. 8	0,75						
61,3	Mean			507	505	86049,81	1,47	86051,28

May 16, A. M. SHANKLIN FARM.

Clock losing $9^s,4$. Barometer 30,03 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
°	h. m. s.	°	°				s.	
59,8	9.29.58	1,20	1,17	507			2,24	
	38.25	1,14	1,11	506			2,02	
	46.51	1,09	1,06	507			1,84	
	55.18	1,04	1,02	507			1,71	
	10. 3.45	1,00	0,98	508			1,57	
	12.13	0,96	0,94	507			1,45	
	20.40	0,92	0,89	508			1,30	
	29. 8	0,87	0,85	508			1,29	
	37.36	0,83	0,81	509			1,18	
	46. 5	0,80	0,78	507			1,00	
60,4	54.32	0,76						
60,1	Mean			507,4	505,4	86050,14	1,56	86051,70

May 16, P. M.

Barometer 30,03 inches.

Temp.	Time of coincidence.	Arc of vibration.	Mean Arc.	Interval in seconds.	No. of vibrations.	Observed vibrations in 24 hours.	Correction for Arc.	Vibrations in 24 hours.
60,6	0.24.40	1,19	1,16	506			2,20	
	33. 6	1,13	1,10	506			1,99	
	41.32	1,08	1,05	507			1,81	
	49.59	1,03	1,00	507			1,64	
	58.26	0,98	0,96	507			1,51	
	1. 6.53	0,94	0,92	507			1,39	
	15.20	0,91	0,89	507			1,30	
	23.47	0,87	0,85	507			1,29	
	32.14	0,83	0,81	508			1,18	
	40.42	0,79	0,77	508			0,97	
60,8	49.10	0,76						
60,7	Mean			507	505	86049,81	1,53	86051,34

Observations for connecting the Stations of the Trigonometrical Survey with those of the Pendulum.

Clifton.

Oct. 9th 1818. The angles of the following triangles were observed, in order to obtain the distance from Clifton Beacon to the Pendulum.

Clifton Beacon from Laughton Spire, 25409 feet.

Clifton Beacon,	83° 22′ 23″	to Station A	934 feet.
Laughton Spire	(2. 6. 0)		
Station A, -	94.31.37		

Clifton Beacon from Station A, 934 feet.

Clifton Beacon,	85° 48′ 29″	to Pendulum Stat.	1380 feet.
Station A, -	58.48.41		
Pendulum Station,	(35.22.50)		

The angle between Laughton Spire and the Pendulum Station is, - -	169° 10′ 52″
Laughton Spire is south west of the Meridian of Clifton Beacon, - -	1.56.12
Hence, the bearing of the Pendulum Station from Clifton Beacon to the N.E. is	12.45.20

Arbury Hill.

On the 26th of October, a base of 906 feet was measured in the meadows at the foot of Arbury Hill, for the purpose of finding the distance from Arbury Hill to the Pendulum

Station. As the house could not be seen, I chose a station (B) near it, which by measurement was 206 feet to the north of the clock. The following triangles were then observed.

From the North end of the Base to the South end, 906 feet.

	° ′ ″		
North end, -	97·37· 5	to Arbury Hill	——
South end, -	54·30·21		1921 feet.
Arbury Hill, -	(27·52·34)		

From the South end of the Base to Arbury Hill, 1921 feet.

	° ′ ″		
South end, -	104·24·17	to Station B.	——
Arbury Hill,	(34·42· 4)		2842 feet.
Station B, -	40·53·39		

Adding 206 feet to 2842, we obtain 3048 feet, for the distance from the Pendulum to Arbury Hill, which was so nearly in the direction of the meridian as to require no correction.

Dunnose.

9th May, 1819, measured a Base of 1140 feet on Shanklin Down, and observed the following readings on the azimuth circle.

Objects.	Readings of the Verniers.	Mean.
At the North end of the Base.		
	° ′ ″	° ′ ″
Summer house chimney, - -	0.42.15 42.50 42.50	0.42.38
South end of base, - - -	106.11.20 11. 5 11. 5	106.11.10
Top of the Signal Post, - -	210.15.40 16.20 15.35	210.15.52
Dunnose Station, - - -	235.50.10 51. 0 50.30	235.50.33
At the South end of the Base.		
Sir Richard Worsleys's Obelisk,	0.25.40 25.35 25.35	0.25.37
Dunnose Station, - - -	57.19.55 19.50 19.45	57.19.50
Top of the Signal Post, - -	57.56.20 56. 5 56. 0	57.56. 8
North end of base, - - -	65.41. 0 40.40 40.35	65.40.45
Summer House chimney, - -	125. 3.25 3.25 3.25	125. 3.25

At Dunnose Station.		
Objects.	Readings of the Verniers.	Mean.
	° ′ ″	° ′ ″
North end of Base, - -	0.17. 0 16.40 16.50	0.16.50
Top of the Signal Post, - -	36.26.20 26.20 26.15	36.26.18
Sir RICHARD WORSLEY's Obelisk,	159.26.20 26.30 26. 0	159.26.17

No. 1. *From the North to South end of Base,* 1140 *feet.*

North end Base, -	105°.28′.32″	to Summer house chimney,	3755
South end Base, -	59.22.40		4205
Summer house, -	(15. 8.48)		

No. 2. *From the North to South end of Base,* 1140 *feet.*

North end Base,	104°. 4′.42″	to Signal Post	165
South end Base,	7.44.37		1191
Signal Post, -	(68,10.41)		

No. 3. In the following triangle, we have given the two sides from the south end of the Base to the Summer house, and from the south end of the Base to the Signal Post and the included angle, to find the remaining angles and the distance from the Signal Post to the Summer house.

South end Base,	67°. 7′.17″	to Signal Post	1191
Summer house,	16.20.38		3900
Signal Post, -	96.32. 5		

The distance from the Signal Post to the gun marking Dunnose station, was found by measurement to be 120 feet, the gun being to the northward, and nearly in a right line with the south end of the base and the Signal Post. This being added to 1191 feet, the distance of the Signal Post from the south end of the Base, we have 1311 feet, for the distance of the gun from the south end of the Base. In the following triangle therefore, two sides, and the included angle, are given to find the remaining angles and the third side.

No. 4. *From the South end of Base to Dunnose Station* 1311 *feet.*

	° ′ ″		
South end Base,	67.43.35	to Summer house	——
Dunnose Station,	(94. 9.24)		3901
Summer house,	(18. 7. 1)		

The following angles are for the purpose of determining the angle at Dunnose station, between the north and south ends of the base.

		° ′ ″
North end Base,	- - -	129.39.23
South end Base,	- -	8.20.55
Dunnose Station,	- -	(41.59.42)

In the triangle No. 4, if from 94°.9′.24″ we subtract 41°.59′.42″ the remainder 52°.9′.42″ will be the angle at Dunnose Station, between the Summer house and the north end of the Base; to which the observed angle between the north end of the Base and Sir Richard Worsley's Obelisk 159°.9′.27″ being added, we obtain 211°.19′.9″, or 148°.40′.51″ for the

angle at Dunnose Station between the Obelisk and the Summer house.

The bearing of Sir RICHARD WORSLEY's Obelisk, according to the Trigonometrical Survey, is 87°.42′.40 north-west from the meridian of Dunnose; therefore the bearing of the Summer house appears to be 60°.58′.11″ north-east, and the resulting distance on the meridian 1893 feet.

May 12th, the following observations were made with the Repeating Circle, for obtaining the Zenith distance of the top of the Signal Post.

Level.		Readings, &c.		
+ 21	— 5			° ′ ″
+ 16	— 12	1st Vernier -		292.54. 5
+ 6	— 22	Second - -		0
+ 7	— 20	Third - -		5
+ 11	— 17	Fourth - -		0
+ 10	— 19			
+ 18	— 10	Mean - -		292.54. 2,5
+ 14	— 18	Index - -	+	13,0
		Level -	—	24,0
+103	—123		+	360. 0. 0
				8) 652.53.51,5
		Zen. Dist. -		81.36.43,9

$$\frac{(+103-123)}{2}\times 2'',4 = -24'',0$$

From the above Zenith distance, and the distance of the Signal Post from the Summer house, we obtain 576 feet, for the elevation of the top of the Signal Post above the Summer house.

The Signal Post was carefully estimated to be 30 feet high, and Dunnose Station is about 7 feet below the base of the Signal Post. Deducting therefore 37 feet, we have 539 feet, for the elevation of Dunnose Station above the Pendulum.

By the Trigonometrical Survey, Dunnose appears to be 792 feet above the level of the sea; the height therefore of the Pendulum above the sea was 253 feet.

Observations with a Barometer of Sir H. ENGLEFIELD's *construction at the Isle of Wight.*

Date.	Thermometer.	Stations.	Barometer. inches.	Calculated height, and correction	Feet above high water mark.
May 12	62°	Summer house, - -	30,078	217,2	
	61	High water mark, -	30,314	+7,0	
	63	Summer house, - -	30,092		224,2
15	62	Summer house, - -	30,036	209,8	
	61	High water mark, -	30,260	+6,7	216,5
16	61	Summer house, - -	30,015	212,8	
	56	Beach (2 ft. above h. water,)	30,227	+7,0	
	61	Summer house, - -	30,008	+2,0	
					221,8
				Mean	220,8
15	60	Dunnose, - -	29,499	707,7	
	61	High water mark, -	30,260	+22,8	
					730,5
	60	Dunnose, - -	29,499	497,4	
	62	Summer house, - -	30,036	+16,1	
					513,4

The correction applied, is $\frac{1}{30}$ of the calculated height on account of the rise of the mercury in the cistern of the barometer.

From the preceding table we have

	Feet.
Dunnose above the Summer house by Trigonometrical measurement, - - - -	539,0
By the Barometer, - - -	513.4
Difference, -	25,6

Summer house above high water mark by the barometer, - - - -	220,8
Add for the fall of the tide, - - -	10,0
Summer house above low water, - - -	230,8
Above low water by the Survey and Trigonometrical observation, - - -	253,0
Difference -	22,2

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AN

ACCOUNT

OF THE

TRIGONOMETRICAL SURVEY

CARRIED ON IN THE

YEARS 1791, 1792, 1793, AND 1794,

BY ORDER OF HIS GRACE THE DUKE OF RICHMOND,

LATE MASTER GENERAL OF THE ORDNANCE.

BY

LIEUT. COL. EDWARD WILLIAMS,

AND

CAPT. WILLIAM MUDGE,

OF THE ROYAL ARTILLERY;

AND

MR. ISAAC DALBY.

COMMUNICATED BY THE DUKE OF RICHMOND, F.R.S.

FROM THE

PHILOSOPHICAL TRANSACTIONS.

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Page 21 line 11, *for* in which the chains were laid off, *read* to which the chains were reduced.

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Page 105 line 2, *for* Direction, *read* Directions.

Page 110 line 11, *for* E and L, *read* R and W.

Page 114 line 4, *for* a degree, *read* the degree.

Page 125 line 19, *for* hopothesis, *read* hypothesis.

Page 145 *et alibi*, *for* Gov. Hornsby, *read* Gov. Hornby.

AN

ACCOUNT

OF THE

TRIGONOMETRICAL SURVEY

CARRIED ON IN THE

YEARS 1791, 1792, 1793, AND 1794.

Read before the ROYAL SOCIETY, *June* 25, 1795.

INTRODUCTION.

A GENERAL survey of the island of Great Britain, at the public expence, was (as we learn from the LXXVth Vol. of the Philosophical Transactions) under the contemplation of Government as early as the year 1763, the execution of which was to have been committed to the late Major General ROY, whose public situation and talents well qualified him for such an undertaking. Various causes procrastinated this event till the year 1783, when the late M. CASSINI DE THURY transmitted a memoir to the French ambassador at London, which paved the way to a beginning of this important work. Calculated for the advancement of science, this memoir was presented to the King, and readily met with the approbation of a monarch, so eminently distinguished, from the æra of his reign, for his liberal patronage of the arts and sciences. By

his Majesty's command, the memoir was put into the hands of Sir JOSEPH BANKS, P. R. S. accompanied with such marks of royal munificence, as speedily obtained all the valuable instruments and apparatus necessary for carrying the design into immediate execution.

General ROY, to whose care the conduct of this important business was committed, lived to go through the several operations pointed out in the memoir, the particulars of which have been detailed at great length in the Philosophical Transactions, where they will remain a testimony of his zeal and ability in conducting so arduous an undertaking at an advanced period of life. The further prosecution of the survey of the island, to which the operations hitherto performed might be deemed only as subservient or introductory, seemed to expire with the General.

The liberal assistance which his Grace the Duke of RICHMOND had on all occasions given to this undertaking; and particularly the essential services performed by Captain FIDDES, and Lieutenant BRYCE, of the corps of royal engineers, in the survey and measurement of the base of verification on Romney Marsh, are acknowledged by General ROY in the strongest terms. A considerable time had elapsed since the General's decease without any apparent intention of renewing the business, when a casual opportunity presented itself to the Duke of RICHMOND of purchasing a very fine instrument, the workmanship of Mr. RAMSDEN, of similar construction to that which was used by General ROY, but with some improvements; as also two new steel chains of one hundred feet each, made by the same incomparable artist. Circumstances thus

concurring to promote the further execution of a design of such great utility, as well as honour, to the nation, his Grace, with his Majesty's approbation, immediately gave directions to prepare all the necessary apparatus for the purpose, which was accordingly provided in the most ample manner.

SECTION FIRST.

An Account of the Measurement of a Base on Hounslow Heath, *with an hundred Feet Steel Chain, in the Summer of the Year* 1791. Reference to be had to Tab. XLIII. and XLIV.

ARTICLE I. *Preamble.*

Previous to entering upon the ensuing account, it may not, perhaps, be improper to enumerate some preliminary matters relative to the subject. The first mode of mensuration adopted by General Roy was that with deal rods, which had also been used and approved of in other countries. In the course of the measurement, however, it appeared, that the sudden and irregular changes which these rods were liable to, from dryness, humidity, or other causes, rendered them totally unfit for ascertaining the length of the base with that degree of precision, of which it was at first thought they were capable. On this account they were laid aside, and glass rods substituted in their stead. These rods were contrived with great ingenuity to answer the purpose, as fully appears by the account given of them in the Philosophical Transactions. But this mode of mensuration being the first of the kind, seemed to require some proof of its accuracy, which consideration induced General Roy to make a comparison between the glass rods and the steel chain, which Mr. Ramsden had made for the Royal

Society. For this purpose a distance of one thousand feet was carefully measured with the rods and the chain. The result of these measurements appeared to be such as would have produced a difference of little more than half an inch upon the whole base, had it been measured with each of them respectively. But notwithstanding the apparent degree of accuracy which this, or any other mode of measuring may be supposed capable of, yet it seems necessary that every base, intended to become the groundwork of such nice operations, ought always (when circumstances will permit) to be measured twice at least.

The manner in which the glass rods were applied in the measurement, is supposed to have rendered the operation liable to some small errors, which lying different ways, might possibly have counterbalanced each other, and produced a true result: but this supposition ought never to be admitted in experimental inquiries, unless such errors can be nearly estimated. The principal cause of error is supposed to arise from the ends of the two adjacent rods being made to rest on the same tressel; because when the first rod is taken off, the face of the first tressel, being then pressed by the end of one rod only, will acquire a tendency to incline a little forward. The error arising from this cause will evidently tend to shorten the apparent base.

Another source of error is supposed to arise from the casual deviation of the rods from a right line, in the direction of the base, tending to increase its apparent length. And a third error is supposed to result from the method which was used, of supporting the ends of the rods on two tressels only, by

which they become liable to bend in the middle. This concave form of the rods would also tend to lengthen the base. The first of these causes of error was submitted to experimental inquiry in the garden of Richmond house, Whitehall, in the presence of his Grace the Duke of Richmond, Sir Joseph Banks, Mr. Ramsden, and Mr. Dalby; when it appeared evidently, that the glass rod had a small motion when the other rod, which had counterbalanced it, was taken from the tressels.

These considerations, therefore, rendered it necessary to compare the measurement with the glass rods, with that performed by some other method; not on account of any doubt being entertained of the care with which General Roy's operation had been performed, but solely with a view to bring this new mode of measuring to some proper test. No method of comparison could, perhaps, be better than measuring the same base with the steel chain. General Roy himself, in his remarks on the comparative accuracy of the two bases, that of Hounslow Heath and Romney Marsh, evidently gives the preference to the chain; which, every circumstance considered, it is certainly right to do. These reasons induced his Grace the Duke of Richmond to direct the base on Hounslow Heath to be remeasured with the steel chain; and although the result does not differ from the glass rods by so small a quantity as General Roy's experiment assigned, yet it does not amount to more than three inches on a base exceeding five miles.

ART. II. *Of the Apparatus provided for the Measurement of the Base.*

The apparatus, provided for the measurement, consisted of the following articles, *viz.*

1. A transit instrument.

2. A boning telescope.

3. Two steel chains, 100 feet each, with the apparatus for the drawing-post and weight-post.

4. Fifteen coffers of deal, for receiving the chain when extended in a right line.

5. Thirty-six strong oaken pickets of $3\frac{1}{2}$ and $4\frac{1}{2}$ feet long; shod, and hooped with iron.

6. Four brass register heads, carrying graduated sliders moved by finger-screws, for adjusting the ends of the chain. One of these registers has a micrometer-screw attached to it, proper for measuring small quantities expanded or contracted by the chain.

7. Thirty-six cast iron heads, to fix on the pickets.

As many of these articles have been described very circumstantially by General ROY in the LXXVth and LXXXth Volumes of the Philosophical Transactions, it will only be necessary here to give a description of the transit instrument, boning telescope, and the two new chains.

1. *The Transit Instrument.* Tab. XLIII.

This instrument, made by Mr. RAMSDEN, may be considered as a transit combined with a telescopic level, which

makes it serve two purposes; one for determining points in the same vertical plane; the other to show how much a measured line deviates from the level. It consists of a telescope about eighteen inches long, with an achromatic object-glass of about $1\frac{6}{10}$ inches diameter. The telescope passes through an axis in the manner of a transit, and as it must be used for viewing objects at very different distances, the images from the object-glass will vary in the same proportion; it therefore becomes necessary to vary the distance of the wires, so that they may be exactly in the same place with the image. For this purpose there is a pinion, moveable by turning a milled head at A, whereby the small tube, with the wires which are contained in the box B, are made to approach, or recede from the object-glass.

The two pivots, or extremities of the axis, are made with great accuracy to the same diameter; and they turn in angles in the uprights C and D. Each of the angles is fixed in a slider; one at D, to move horizontally, by turning a finger-screw E; the other vertically, by turning the finger-screw F.

The level G is here represented as suspended by its hooks on the transverse axis. Its use is to shew when that axis is horizontal; and it is furnished with an adjusting-screw H, by which the two hooks may be made exactly of the same length, so that the axis on which it is suspended may become parallel to a tangent to the middle of the glass tube. This level also serves to set the line of collimation in the telescope horizontal; for which purpose there are two pins, K and L, attached to the side of the telescope, parallel to the axis thereof: one of these pins is furnished with an adjusting-screw M, by which the

the line of the hooks is made parallel to the line of collimation in this direction, with the greatest precision. The level may be suspended on these pins in the same manner as on the horizontal axis.

The cross wires at N, in the common focus of the object and eye-glasses, are fixed at right angles to each other; but instead of being placed horizontally and vertically, as in the common way, they make each an angle of 45° with the plane of the horizon. This mode of fixing wires is of the greatest advantage in making nice observations, as it remedies the inconvenience and error arising from their thickness. To bring the line of collimation in the telescope at right angles to the horizontal or transverse axis, there are two nuts for the purpose, one on each side of the box at N, which serve to move the intersection of these wires towards the right or left.

In the eye end of the telescope is a micrometer, which serves to measure small angles of elevation or depression. It consists of a moveable horizontal wire, placed as close as possible to the cross wires already mentioned. By turning the micrometer-screw O, this wire is moved across the field of the telescope, and the space which it moves through is shown in revolutions of the micrometer-screw, by means of an index, moveable in a slit, and the divisions on the stem Q. The parts of a revolution are shown in 100ths by an index P, on the micrometer head.

In tracing out a base by intermediate stations, the instrument must be frequently shifted to the right or left, till the telescope shows that the middle of its axis and the extremities of the base are in the same vertical plane. To expedite this

operation, there are slits cut through the top of the mahogany board, for receiving the screws which fasten the supports of the telescope; by which means the telescope, with its supports, can be moved a little to the right or left, whilst the stand remains fixed. Over another slit in the top, and directly under the centre of the axis of the telescope at R, is a small hole for a wire or thread to pass through, suspending a plummet for marking a point on the ground, when the telescope is brought into the desired vertical plane.

The method of levelling the axis, adjusting the line of collimation, &c. are similar to those for the upper telescope of the great theodolite, as described in the Philosophical Transactions.

2. *The Boning Telescope.*

This telescope is in every respect the same as that which was made use of by General Roy, therefore it will only be necessary to explain the application of it, for fixing the pickets in the direction of the base, with the tops of those belonging to the same hypotenuse in the same right line.

A rope being stretched along the ground, in the direction of the base, distances of 100 feet were marked upon it by means of a twenty-feet deal rod. After a sufficient number of these distances were set off, the telescope was laid on a narrow piece of board, truly planed, and fixed to the top of the picket at the beginning of the hypotenuse; and another picket was driven into the ground at a convenient height at the other end. To the top of this last, a thin deal spar was fixed, and the telescope directed to it, whilst the intermediate pickets were driven to

their proper height. To determine this height more accurately, another spar, whose thickness was equal to the height of the axis of the telescope above the top of the picket, which supported it, was repeatedly laid on the top of each picket at the time of driving it, till its upper edge and the fixed spar appeared in a right line. Whilst the pickets were driving, they were moved a little to the right or left, as directed by signals from the observer at the telescope, till their tops appeared in the same right line.

3. *The Chains.*

These chains were made by Mr. RAMSDEN, and are of similar construction in the joints to that which he made for the Royal Society, described in the LXXVth Volume of the Philosophical Transactions; but they differ from that in other respects. Instead of one hundred links, each of these new chains contains forty, of $2\frac{1}{2}$ feet long. The link is in form of a parallelopipedon, of half an inch square, which renders it considerably stronger than that of the Royal Society; and the chain having fewer links, becomes less liable to apply itself to any irregularities which the coffers may be subject to. The handles are of brass, and being perfectly flat on the under side, they move freely upon the brass register-heads, by which means the coincidence between the arrows at the extremities of the chain, and the divisions on the scales, are readily and accurately obtained. The two chains will hereafter be distinguished by the letters A and B.

On Saturday July the 23d, all the foregoing articles were conveyed from the Tower to the end of the base near King's

Arbour, where tents were pitched for a party of the royal regiment of artillery, consisting of one serjeant and ten gunners, who were to be employed in the laborious part of the operation.

ART. III. *Experiments made to ascertain the relative Lengths of the Chains, before and after they were used; and also to determine the Expansion of one Chain, or one hundred Feet of blistered Steel, by one Degree of* FAHRENHEIT'S *Thermometer.*

For this purpose, two strong oaken pickets were driven two feet into very firm ground, and the drawing-post was made fast to them. Five coffers were arranged in a right line, and supported upon courses of bricks. The chain was then placed in the coffers, and stretched with a weight of fifty-six pounds. Notwithstanding the great resistance which it was thought these pickets were capable of, yet it was found insufficient to counteract the friction between the coffers and the chain, when the expansion or contraction took place. Three pickets, therefore, of forty-four inches long, were driven into the ground, within six inches of their tops, and the drawing-post was fastened to them by several folds of strong rope. The pickets and rope were also covered with earth, to prevent their being warped by the sun.

The micrometer-screw, attached to the brass register-head, by means of which the expansion or contraction was measured, contains 26 threads in an inch. The circular head is divided into 10 equal parts, and consequently each division will measure $\frac{1}{260}$th part of an inch. But as the eye readily subdivides

each of the divisions into 4 parts, the micrometer will measure the $\frac{1}{1040}$th of an inch tolerably exact.

For finding the relative Lengths of the Chains.

In order to accomplish these experiments in the most unexceptionable manner, after the chain was properly stretched in the coffers, and the thermometers placed by it, the whole remained till all the thermometers stood steadily at the same height. The ends of the chain being then in perfect coincidence with particular divisions on the brass register-heads, the chain was quickly taken out and replaced by the other, which being properly stretched in a right line, and a coincidence made at the drawing-post end of the chain, the variation of the other end from the division on its register-head showed the difference of the lengths of the chains, which was measured by the micrometer. As it required weather particularly steady to succeed in these experiments, we were obliged to catch the most favourable opportunities that presented themselves, which happened on the 29th and 30th of July; on those days the chains were compared with each other, and the results were as follow.

July 29th. *Thermometers remaining steadily at 75° during and after the operation.*

The chain B was found to be $6\frac{1}{2}$ divisions of the micrometer head shorter than the chain A; and on being shifted, A was found to exceed B $6\frac{1}{2}$ divisions.

Same day. Thermometers steady at $67\frac{1}{2}$°.

The chain B 6 divisions shorter than A; and being shifted, the chain A was 6 divisions longer than B. The mean from these experiments is, A $6\frac{1}{4}$ divisions longer than B.

In the table containing the particulars of the operation it will be found, that the chain B was laid aside after measuring 38 chains, on account of one of the links appearing to be a little bent. Before it was sent to Mr. RAMSDEN it was compared with the chain A (at first intended to be kept as the standard chain), when it was found to be only $4\frac{1}{2}$ divisions longer; which being $1\frac{3}{4}$ divisions less than the mean $6\frac{1}{4}$ as found above, shows, that the chain B had lengthened $1\frac{3}{4}$ divisions in measuring 38 chains; for when Mr. RAMSDEN afterwards straightened the link, he could not perceive any difference in its length.

The remainder of the base was measured with the chain A (the chain B being kept as a standard), and when that was completed, a comparison was again made between A and B, when it appeared that A exceeded B by $14\frac{2}{10}$ divisions of the micrometer head; therefore the wear of A, by lengthening of the joints, in measuring 236 chains, was 14,2 — 4,5 divisions = 9,7 divisions of the micrometer.

For finding the Rate of Expansion.

The chain being placed in a right line, along the horizontal bottoms of the coffers, and kept in a state of tension by a weight of fifty-six pounds, five thermometers were placed close by the chain; one in the middle of each coffer; and the whole was covered with a white linen cloth, when the sun shone out. After remaining a few minutes, till the thermometers were nearly of the same temperature, a perfect coincidence was made on the register heads, at each end of the chain, and the thermometers noted. Every thing remained in this state till the coincidence at the weight end of the chain was ob-

served to be altered, and the thermometers nearly the same; at which instant, they were again read off, and the alteration of coincidence measured by the micrometer.

August 5th, cloudy.

Thermometers.							Total contr.	Contr. on 1°.
1	2	3	4	5	Mean.	Micr. Divisis.	Inches.	Inches.
75,75	75,5	76	76,25	76	75,9	$25\frac{1}{8}$	,096642	,0074
62,5	62,75	63	63	63	62,85			

Here the contraction of the chain is $25\frac{1}{8}$ divisions of the micrometer $= 25\frac{1}{8} \times \frac{1}{260}$ inches $=$,096642 inches, and the corresponding variation of the thermometers, taking the difference of the means, is 13°,05; consequently the contraction on $1° = \frac{,096642}{13,05} =$,0074 inches.

Aug. 6th, cloudy.

89,5	89,75	90	90	90,5	89 95	38,5	,148077	,00719
69,5	69,5	69,25	69	69,5	69,35			

Aug. 7. Coffers covered with the linen cloth.

102,5	102,5	102,75	102	102	102,35	29,5	,113462	,00749
87	86	87	88	88	87,2	8	,030769	,00779
89	89,75	93	92	92	91,15	16,25	,062500	,00781
98	95	102	99,75	101	99,15	9,33	,035885	,00748
93	92	96	95	95,75	94,35			

Aug. 7th, in the evening. Coffers covered with the linen cloth.

Thermometers.							Total contr.	Contr. on 1°.
1	2	3	4	5	Mean.	Micr. Divisis.	Inches.	Inches.
90	91	89	91	92	90,6			
80	80	81,5	81,5	81	80,8	19	,073077	,00746
67	68	69,5	69	69	68,5	23,5	,090385	,00735
60,75	62,75	62	62	62	61,8	13	,050000	,00746

The mean result from these nine experiments is 0,007492, or 0,0075 inch to 1° of FAHRENHEIT, on 100 feet of blistered steel; which differs only $\frac{13}{100000}$th parts of an inch from General ROY's conclusion with the pyrometer; but the number ,0075 is preferred in these measurements, as being deduced from experiments made with the chain itself.

ART. IV. *Particulars relative to the Commencement of the Operation*, &c.

After the chains were compared, and the rate of expansion determined, as related in the preceding article, several trials were made of arranging the pickets and coffers in such a manner as might be supposed proper for the reception of the chain. It was soon found, however, that this method of measuring would be neither so expeditious or accurate, as if the coffers were placed upon tressels, such as were made use of by General ROY in his measurement with the glass rods. An application was therefore made to Sir JOSEPH BANKS, who very

obligingly complied with the request, and lent the tressels belonging to the Royal Society; a description of which may be seen in the LXXVth Vol. of the Philosophical Transactions.

As the upper part of the pipe at the north-west end of the base was found to be exceedingly rotten, it became necessary to saw off 13 inches of it, which left enough of the cylinder remaining to fix the brass cup in, as it had been originally bored to the depth of two feet. This cup, which was also lent by the Royal Society, being inserted in the pipe, fitted it exactly.

On the 15th of August, having previously traced out the line of the base, by means of the transit instrument, the operation commenced, in the presence of Sir Joseph Banks, Dr. Maskelyne, and several other members of the Royal Society. The following table, which contains the particulars of it will explain the order of time in which the different parts of the measurement were performed. As it would swell this table to a great extent, were the degrees shewn by the thermometers inserted therein, it has been considered as proper to give only their sum, which is sufficient for finding the correction to be applied in the reduction of the base, on account of the lengthening or contracting of the chain by variation of temperature. It may, however, be remarked, that the five thermometers were laid close by the chain, and suffered to remain till they had nearly the same temperature, when they were read off, and registered in a field-book, whilst an observer at each end of the chain preserved a perfect coincidence between the arrow and a particular division on the brass scale. When the sun shone out, the chain was covered with a white linen cloth, the ends of which were put over the openings of

the first and last coffers, to exclude the circulation of air. The thermometers usually remained in the coffers from 7 to 15 minutes, according to circumstances; when the sky was much overcast, a shorter time generally was found to be sufficient.

ART. V. Table, containing the Particulars of the Measurement: the first Column showing the Day of the Month when each Hypotenuse was finished; the Second, the Number of Hypotenuses; the Third, the Number of Chains in each Hypotenuse; the Fourth, the Perpendicular belonging to each Hypotenuse, or the *datum* for reducing it to the Plane of the Horizon; the Fifth, the computed Reduction; the Sixth, the new Points of Commencement above or below the Head of the last Picket when a new Direction was taken; the Seventh, the total Descent of the Extremity of each Hypotenuse; and the Eighth, Remarks, or general Occurrences.

1791. Month.	No. of hypoten.	No. of chs. in hypoten.	Perpendicular.	Reduction of hypotenuse.	New point of commt.	Total descent.	Remarks.
			Inches.	Inches.	Inches.	Inches.	The 1st chain commenced 14
Aug. 15	1	3	5,8	0,00467	1,8	19,8	inches above the head of Ge-
16	2	3	0,0	0,00000		21,6	neral Roy's pipe before it
22	3	32	57,	0,04231		35,4	was cut off smooth.
23	4	14	26,25	0,02051	4,9	61,65	Began measuring with chain A
25	5	10	12,1	0,00610	7,9	68,85	at 4th hyp. one of the links on
29	6	19	0,0	0,00000		60,95	the chain B appearing to be a
Sept. 2	7	34	28,8	0,01017		89,75	little bent. [8th hypot.
4	8	1	3,8	0,00602		85,95	Crossed the river Coln at the
6	9	15	69,25	0,13321	4,25	155,20	Crossed the Staines road at the
8	10	17	15,3	0,00574		166,25	9th hypotenuse.
9	11	5	33,5	0,09352		199,75	
12	12	13	1,9	0,00012	8,25	201,65	
12	13	7	54,5	0,17680		247,90	
13	14	6	0,0	0,00000	5,25	247,90	
14	15	5	7,5	0,00469		250,15	
14	16	9	0,0	0,00000	9,5	250,15	
16	17	8	5,3	0,00146		245,95	
17	18	10	2,9	0,00035		248,85	
20	19	5	4,8	0,00192		253,65	
20	20	4	8,1	0,00683		261,75	
21	21	8	1,5	0,00012		260,25	
21	22	6	35,4	0,08703		295,65	
22	23	1	6,4	0,01707		302,05	Crossed the Wolsey river at the
23	24	10	14,5	0,00876		316,55	23d hypotenuse.
25	25	12	54,4	0,10275		370,95	
25	26	1	24,5	0,25015		346,45	
25	27	5	1,0	0,00001		345,45	
26	28	5	11,3	0,01064		356,75	
26	29	1	9,0	0,03375		365,75	The head of the last picket was 2½ feet above the head of
26	30	5	6,9	0,00397		372,65	the pipe before it was cut off smooth.
		Total reduction =		1,02867	=0,08572 feet.		

Sum of all the degrees shown by the thermometers = 96795,25.

ART. VI. *Further Remarks; and Reduction of the Base to the Temperature of 62°.*

Remarks.

It having been our wish, that some scientific persons should be present at the completion of the measurement, his Grace the Duke of RICHMOND was pleased to desire Dr. MASKELYNE, astronomer royal, and Dr. HUTTON, professor of mathematics in the royal military academy at Woolwich, to attend upon this occasion; to whom Mr. RAMSDEN was necessarily joined, as his standard brass scale, and beam compasses, were requisite to conclude the business with the wished for accuracy. Accordingly, on Wednesday the 28th of September the remaining three chains were measured in their presence; and the horizontal distance from the end of the last chain to the axis of the pipe was found to be 21,055 inches, as determined by Mr. RAMSDEN; and consequently the apparent length of the base was 274 chains, and 21,055 inches.

The height of the last picket above the pipe was 35 inches, from which deducting the 5 inches of the rotten part, which was cut off, there remains 30 inches, or 2½ feet, for the height of the last picket, above General ROY's pipe; which makes the whole descent 33,55 feet; or about 2¼ feet more than was determined by the former measurement.

Reduction of the Base to the Temperature of 62°.

	Feet.
Apparent length, namely, 274 chains + 1,755 feet - - - - -	27401,755
The correction for the excess of the chains lengths * above 100 feet, and half their wear, is $\frac{236 \times ,0956 + 38 \times ,05489}{12}$; and this add - -	2,0539
The sum of all the degrees shewn by the thermometers was 96795,25; therefore $\overline{\frac{96795,25}{5} - 54^\circ} \times 274 \times \frac{,0075}{12}$ is the correction for the mean heat in which the base was measured, above 54°, the temperature in which the chains were laid off; and this also add - - - -	2,8519
Hence these corrections, added to the apparent length, give - - -	27406,6608
Again, for the reduction of the base to the temperature of 62° we have $\frac{8^\circ}{12} \times 3,38938$; and this subtract - - - - -	2,2596
By the table, the sum of all the corrections for reducing the several hypotenuses to the plane of the horizon is 1,02867 inches = 0,08572 feet; and this subtract - - - -	0,0857
Hence these corrections taken from the above length leaves that of the base in the temperature of 62° - - - -	27404,3155

* For the lengths of the chains A and B see ART. VII. of this section.

To compare this length of the base with that assigned by General Roy, it becomes necessary to rectify a small oversight in the 4th step of the process published in the Philsophical Transactions for 1785.

The equation for 6° difference of temperature there specified, should consist of the *difference* of the numbers for brass and glass, and not of that for brass alone, *viz.* $\frac{6^{\circ}}{12} \times \overline{3,38938 - 1,41658} = 0,9864$ feet instead of 1,6946, which makes the base 0,7082 feet too long. Therefore the length of the base, as measured by the glass rods, is 27404,0843 feet, being about $2\frac{3}{4}$ inches less than by the above reduction; consequently 27404,2, the mean of the two results, may be taken as the true length of the base.

ART. VII. *Mr.* Ramsden's *Method of ascertaining the actual Lengths of the Chains* A *and* B. Tab. XLIV.

These chains were originally compared with the brass points inserted in the stone coping of the wall of St. James's churchyard; but the temperature at the time of that comparison was afterwards forgotten by Mr. Ramsden. After the mensuration on Hounslow Heath was finished, the chains were again compared with those points; but the result did not prove to be satisfactory, as there were reasons for supposing that some alteration had taken place in the length of the coping; but, independent of this, the great irregularities between the joints of the stones, some of which projected half an inch above others, rendered it at best a very rude and inaccurate operation. Mr. Ramsden had points remaining on his great plank, which had been transferred from the brass standard, but as the plank

itself was found to be subject to a daily expansion and contraction, he turned his thoughts to the invention of some other method of measuring the lengths of the chains, in a more unexceptionable manner.

On considering that the expansion of cast iron is nearly the same as that of the steel chain, he procured a prismatic bar of that metal, of 21 feet long, judging it to be the most proper material for the present occasion, as well as for establishing a permanent standard for future comparisons of the same kind. The manner in which the bar was fitted up for the purpose will be readily understood by attending to Tab. XLIV.

The great plank was cut to the length of about 22 feet, and on one of its narrow edges 21 brackets were fixed; each of which had a triangular notch to receive and support the bar, with one of its angles downwards, so that the upper surface became one of the faces of the prism. Before the brass points were inserted in this bar, Mr. RAMSDEN compared his brass standard with that belonging to the Royal Society, for which purpose, on Nov. 22d, 1791, it was sent to their apartments in Somerset house, where, after the two standards had remained together about 24 hours, they were found to be precisely of the same length. Brass points were then inserted in the upper surface of the bar, from Mr. RAMSDEN's standard, at the distance of forty inches from each other, the whole length of 20 feet being laid off on those points in the temperature of 54°.

The chains were measured in the Duke of MARLBOROUGH's riding-house, where the light was very convenient for the purpose, and the whole apparatus was sheltered from the wind and sun. The plank and bar were supported on five of the tressels, or tripods, belonging to the Royal Society, and the upper sur-

face of the bar was brought into an horizontal plane by means of screws and a spirit level. The brass points on the upper surface of the bar were brought into a right line, by stretching a silver wire along the top, and pressing the bar laterally with wedges, till all the points fell under the wire. Part of the chain was then placed on rollers, which rested on narrow slips of wood fixed on the side of the plank, about five inches below, and exactly parallel to the bar; and whilst it was fastened to an adjusting-screw near one end of the plank, it was kept straight on the rollers by a weight of fifty-six pounds.

From the extremities of the 20 feet on the edge of the bar, two fine wires with plummets were suspended, which were immersed in vessels of water, the wires hanging so as nearly to touch the chain. One end of the chain being then brought under its wire, by means of the adjusting-screw, a fine point was made on the chain coinciding with the other wire. This part of the chain was then shifted, and another 20 feet measured in the same manner; and the operation continued till the length of each chain was thus obtained at five successive measurements. The result was, that in the temperature of $51\frac{1}{2}°$, in which the operation was performed, the chain A was found to exceed 100 feet by 0,114 inches, and the chain B, by 0,058 inches. Now, according to the table of expansions in Vol. LXXV. Phil. Trans. the expansion due to 1° FAHRENHEIT on 100 feet of cast iron is 0,0074 inches, and that of the chain being 0,0075, their difference is 0,0001, and therefore for $2\frac{1}{2}°$ it will be 0,00025; consequently, as the points were put on the bar in the temperature of 54°, and the chains measured in $51\frac{1}{2}°$ or $2\frac{1}{2}°$ less, their lengths in the temperature of 54°, agreeing with the points on the bar, will be

$$\begin{array}{l} \quad\text{feet.}\quad\text{inches.} \\ A = 100 + 0{,}11425 \\ B = 100 + 0{,}05825 \end{array}$$

The comparison of the chains with each other, as related in ART. III. together with this determination of their lengths, furnish the *data* necessary for the reduction of the base on Hounslow Heath.

The wear of B, in measuring 38 chains, appeared (vid. ART. III.) to be $1\frac{3}{4}$ divisions of the micrometer head $= \frac{1{,}75}{260} =$ 0,00673 inches: and the wear of A was 9,7 divisions $= \frac{9{,}7}{260} =$ 0,0373 inches.

	Inches.		Inches.
Then, from the excess of A above 100 feet, namely, - -	0,11425,	and of B	0,05825
subtract half the wear -	0,01865		0,00336
	0,0956		0,05489

And we get the lengths of the chains in the temperature of 54 deg. before they were used in the measurement, namely, . $\left\{\begin{array}{l} A = 100\text{ Ft.} + {,}0956\text{ In.}, \text{ and} \\ B = 100 + {,}05489, \text{ the lengths used in the re-} \\ \text{duction of the base.} \end{array}\right.$

ART. VIII. *Method of fixing the Iron Cannon at the Extremities of the Base on* Hounslow Heath, 1791.

As the pipes were found in a very decayed state, and it became certain, were they suffered to remain as the *termini*, that in a few years the points marking the extremities of the base would be lost, it became necessary to re-establish them in a more permanent manner. Amongst the various means

which were proposed for this purpose, that of heavy iron cannon was adopted, having been previously sanctioned with the approbation of Mr. RAMSDEN, and other competent judges. Two guns were therefore selected at Woolwich by order of the Master-general, from among those which had been condemned as unfit for the public service, and sent to Hampton by water.

The placing of these guns accurately being an operation of a delicate nature, and attended with some difficulty, on account of their great weight, the mode of performing it was very deliberately considered; and every precaution afterwards taken to render the operation unexceptionable. The method was as follows.

Four oaken circular pickets, of 3 inches diameter, were driven into the ground, at the distance of 10 feet each from the centre of the pipe, two of them being in the direction of the base, and the others at right angles to it. Melted lead was then run into a hollow made in the head of each picket, and afterwards filed off perfectly smooth. On the brass cup, belonging to the Royal Society, being adjusted in the pipe, silver wires were stretched from the heads of the opposite pickets, and moved till their intersection coincided with the centre of the cup; and in this position a fine line was drawn on the lead of each picket, exactly under and in the direction of the wire. This operation being performed, and the truth of it reexamined, the pipes were taken out of the ground, in doing which it became necessary to make an excavation of about four feet, in order to clear the circumference of the wheel. It had been at first intended to have inserted the gun so far in the ground as that its muzzle should be even with the surface of

the original pipe: but upon considering that this was a matter not absolutely essential to the ascertaining of the actual length of the base by any future measurement, provided the axes of the guns were made to coincide with those of the pipes, it was determined to fix the cannon, without digging the pit to a greater depth than that of ten feet. In this position, however, it was evident, that the muzzle of the gun would rise higher than the surface of the pickets, which had been put into the ground for finding the centre; which rendered it necessary to drive in and adjust four outer pickets, of a proper height, to determine the centre of the bore of the gun, by the intersection of another set of wires. The tops of the first set of pickets were therefore cleared, and the silver wires extended along the fine lines which had been made on the lead. A plummet was then suspended from above, and moved till it fell on the intersection of the wires. Being fixed in this position, another set of wires was stretched across the tops of the four outer pickets, till their intersection also coincided with the vertical wire of the plummet, in which position, fine lines were drawn under the wires on the top of each of the outer pickets. The truth of the operation now depending on these last pickets, they were carefully guarded by another set which surrounded each of them, and these last were again bound round with ropes, to preserve the centre pickets from any possible accident. These precautions being taken, and the pit cleared, a large stone of $2\frac{1}{2}$ feet square, and 15 inches deep, containing a circular cavity in its upper surface to receive the cascabel of the gun, was placed in the bottom of it, the centre of the hole being nearly under the intersection of the wires, as determined by a plummet. The gun was then

let into the pit, and resting upon the stone, it was brought into a position nearly vertical, at which time a quantity of earth and stones were thrown into the pit sufficient to steady the gun. This being done, the cross wires were stretched over the outer pickets, and a pointed plummet suspended from above, having its line coinciding with the intersection of the wires, was let fall into the cylinder, in which a cross of wood that exactly fitted it was placed, whose centre corresponded with that of the bore. The gun was then moved till a dot marking the centre of the cross came directly under the point of the plummet; when earth and stones were rammed round the gun, care being taken to force it by that operation into its proper position, as shown by the plummet and cross. In this manner were the guns fixed at the extremities of the base; and it remains only to be observed, that to prevent the unequal settling of the earth, rammed within the pit, from moving them out of their proper positions, four beams of wood were placed in an horizontal direction, having their ends resting against the sides of the pit and the gun. It may also be added, that iron caps were screwed over the muzzles to preserve the cylinders from rain.

SECTION SECOND.

Containing Particulars relative to the Commencement of the Trigonometrical Operation.—An Account of the Improvements in the great Theodolite; and a Relation of the Progress made in the Survey in 1792, 1793, *and* 1794, *together with the Angles taken in those Years.*

ART. I. *Of Particulars relative to the Commencement of the Trigonometrical Operation.*

Having, by the re-measurement of the base on Hounslow Heath, sufficiently determined its accuracy, it became necessary, upon the approach of the following spring, to form some plan which might enable us to commence the survey with the most advantage.

Of those which were suggested, that of proceeding immediately to the southward with a series of triangles seemed the most eligible, not only because, in the first instance, the execution of it would forward one great design of the business, in an early determination of some principal points upon the sea-coast, but also because a junction of the eastern part of the series with that of the western of General Roy, would afford an early proof of what degree of accuracy had attended both operations.

To ascertain the truth of the General's work, by verifying some principal distance or distances, was an object which presented itself, not only as interesting and curious, but as highly necessary, in order to determine whether, by the result, the triangles might stand good, and become a part of the general series.

In addition to this reason, there was another which offered itself, and that was, the prospect of being able to obtain the length of a degree of longitude in an early stage of the survey; for it had been suggested, and upon inquiry was found to be true, that Dunnose in the Isle of Wight was visible, in particular moments of fine weather, from Beachy Head on the coast of Sussex: but attention was at the same time given to the recommendation of General Roy, in the selection of Shooter's Hill and Nettlebed, as places for observing the directions of the meridian; and it was resolved, whatever preference might in future be given to those on the coast for this important operation, that at all events such observations should be made, as might determine the distance between the stations recommended by the General.

Having therefore formed an outline for the operation of the year 1792, upon the approach of spring, Captain Mudge and Mr. Dalby explored the country over which it was intended to carry the triangles, and visited such stations in the series of General Roy as were judged to be proper for the above purpose.

In the choice of those stations which were about to be selected, instructions had been given by his Grace the Duke of Richmond to avoid towers and high buildings, as getting an instrument on them had, by the experience which the former operation afforded, been found difficult and dangerous; such of them therefore as were thus circumstanced were avoided, and near the most proper ones, stations were chosen on the ground. From these directions the points of junction were necessarily confined to Saint Ann's Hill, Botley Hill, and Fairlight Down, because the pipe sunk near Hundred Acre House

was found to be destroyed; but this was considered immaterial in its consequence, as it would have been improper to have chosen it for a principal station, because the high ground near Warren Farm took off the view of Leith Hill.

A disadvantage however, which seemed to result from this resolution of avoiding high buildings for stations, occurred in the difficulty which offered itself of proceeding from Hanger Hill and St. Ann's Hill, with a mean distance of that side as given by General Roy; for the station chosen at the former place being on the ground, there was scarcely a possibility of erecting a staff at King's Arbour, sufficiently high to afford a view of its top from Hanger Hill: a quadrilateral therefore, similarly posited, could not be fixed on; but as a proper substitute, a station was chosen upon the elevated ground near Banstead, which was visible from St. Ann's Hill, King's Arbour, and Hanger Hill; and this, together with St. Ann's Hill and Hanger Hill, formed two triangles, which would give the distance between St. Ann's Hill and Banstead, independent of each other.

Upon the return of Captain Mudge and Mr. Dalby from their expedition, in which they had selected many of the principal stations, and, by examining the face of the country, had formed some judgment of the future disposition of the triangles, preparations were made for taking the field; and the party which had been engaged in the measurement of the base, were ordered to be attached to the trigonometrical operation.

Little difficulty was found in determining upon the choice of the necessary apparatus. Lamps were constructed, by Mr. Howard of Old-street, which were afterwards found to equal

every thing which could be expected from them. Instead of the reflector being exposed to the wind, these lamps were inclosed in strong tin cases, having plates of ground glass in their fronts, which effectually prevented the bad effects of an unequal and unsteady light. In the centre of the back of each case, there were straps and semicylinders of tin, which moving upon joints, clasped the staff to which in their use they were braced. Two of the lamps were of twelve inches diameter, and a third of twenty-two; and the last of these, prior to the use of it in the ensuing season, was lighted on Shooter's Hill, and clearly distinguished at the distance of thirty miles. Copper nozles of different sizes were likewise provided for holding the white lights.

During the measurement of the base, an observatory for the reception of the instrument was making at the Tower, as likewise two carriages, to be used in conveying them from station to station. One was made with springs for the greater safety of the instrument, which resting upon a cushion in the carriage, was sufficiently secured from any jolting upon the road.

As it was easily foreseen that upon eminences, on which it was certain the instrument would be placed, it would be hazardous to trust it in a receptacle of slight construction, great pains had been taken to make the observatory strong. It consisted of two parts, the interior one of which, or the observatory itself, was eight feet in diameter, and its floor of a circular form, and from the sides of it eight iron pillars rose to the height of seven feet, which were connected at the extremities by oaken braces. The roof was formed of eight rafters which united at the top, having their ends fastened into the heads of

the iron staunchcons, and were otherwise sufficiently clamped. The sides and roof were each composed of four-and-twenty frames, covered with painted canvas, any of which could be removed at pleasure; and the whole was covered with a tent formed of strong materials.

Having thus detailed, in as short a manner as possible, the heads of such particulars as it may be necessary the public should be acquainted with, it remains only to give some account of the improvements in our great theodolite, before we narrate the progress made in the survey in the summer of the year 1792.

ART. II. *Account of the Improvements in the great Theodolite.*

Mr. RAMSDEN has considerably improved this instrument, which, in other respects, is of the same dimensions and construction as that made use of by General ROY, which has already been described in the Philosophical Transactions. The construction of the microscopes render them very superior to those of that instrument; as the means by which the image is proportioned to the required number of revolutions of the micrometer-screw, and also the mode of adjusting the wires to that image, are much facilitated. (See Phil. Trans. Vol. LXXX. p. 146.). For the first, there are three prongs proceeding from the cell which holds the object-glass; these, after passing through slits in the small tube which constitutes the lower part of the microscope, are confined between two nuts which turn on this small tube, so that by turning the nuts, the object-lens is moved towards, or from, the divisions on the circle, as occasion may require. To adjust the wires in the micrometer to the image; in the upper part of the body of the microscope

are two nuts, one sliding within the other. To the upper end of the interior one the micrometer is fixed; and near the lower end are three prongs similar to those above mentioned, but something longer. These prongs pass through slits in the exterior tube, and are confined between nuts, in the same manner as the object-lens. This construction has many advantages over that described in the Philosophical Transactions.

To obviate the necessity of the gold tongue (Phil. Trans. Vol. LXXX. p. 147), besides the moveable wire in the field of the microscope, there is a second one, which may be considered as fixed, having only a small motion for its adjustment. When the instrument is adjusted, and the index belonging to the micrometer-screw stands at the *zero* on its circle (the moveable wire cutting one of the dots on the limb of the instrument), this fixed wire must be made to bisect the next dot; as by this means it may be perceived at any time, whether the relative position of the wire has varied.

By graduating the limb of the instrument to every ten minutes instead of fifteen, we are enabled to measure by the micrometer-screw, not only the excess of the measured angle above any of the ten minutes, but also its complement to the next division on the circle, and thereby to correct any small inequality which may happen between the divisions.

ART. III. *Particulars relating to the Operations of the Year* 1792.

Although it might have been reasonably supposed, that the angles of the triangle King's Arbour, Hampton Poor House, and St. Ann's Hill, had been observed with sufficient accuracy in 1787, yet that this operation might not rest on *data* afforded

by any former one, it was considered as proper to determine them with our own instrument.

By a reference to the Philosophical Transactions, (Vol. LXXX. p. 162.) it will be found, that General Roy was obliged to elevate the instrument at the extremities of the base; for which purpose a stage of thirty-two feet high had been constructed. The same necessity existing with us, an application was made to the Royal Society for it; and in the autumn of 1791, that part of it which had been left at Dover, was brought to the Tower.

The first station to which the instrument was taken this year was Hanger Hill, because it was found upon examination, that the part of the stage which had been left at Shepperton was much damaged, and stood in need of considerable repair. It was, however, soon fitted for use, and a new tent for the top having been provided, the half stage was erected over the pipe at St. Ann's Hill, to which from Hanger Hill the instrument was conveyed. Here, as well as at the other stations where the stage was used, a plumb-line was let fall from the axis of the instrument over the point marking the station, being sheltered from the wind by a wooden trough. In the use of the half stage, the instrument was sufficiently steady when the wind blew moderately; but from the crazy state of the lower part, it was only by watching for moments particularly calm, that satisfactory observations could be made when the whole of it was used.

The following obervations will sufficiently explain the detail of this year's operations, which are given in the order of time in which they were made. By an examination of them it will be perceived, that most of the angles have been observed

more than once: indeed it was a position which we laid down upon our commencing this business, and which, as far as circumstances would admit, has since been adhered to, namely, that of observing the angles upon different arcs. When staffs were erected, which was generally the case when the stations were not more remote than fifteen miles, the angles were repeated till their truth became certain, and the same was also done, when angles were determined by the lamps; but it sometimes happened, that only one of the two white lights, which were burned at the distant stations, was seen; in which case, if the observation appeared to be made without any error, but that which an inequality in the division of the instrument might be supposed to produce, it was considered as sufficient; otherwise fresh lights were sent to the station and observed.

In the use of the white lights, it is conceived that sufficient precautions were taken, as the firing of them was always committed to particular soldiers of the party, selected from the rest on account of their capacity and steadiness, who had instructions to place the copper nozle immediately over the point marking the station, by means of a plumb-line let fall from the bottom. In observing them with the instrument, the angle was not taken till the light was going out. But the men commonly guarded against the flame being blown greatly on one side, by erecting something to windward of the light.

In the use of the lamps also, care was taken to give them their proper direction; for when the ground about the station would not admit of the lamp being placed immediately upon it, slender staffs were erected supported by braces, and made upright, by being plumbed in directions at right angles to each other. Precautions were also used to put those staffs pre-

cisely over the points, by centering the holes in the cross-boards.

To such a part of the staff as was judged to be the most convenient, the lamp was buckled, and its direction obtained by bringing a mark in the middle of it to correspond with another on the staff, which was determined to be opposite the station, by directing a ruler to it from each side of the staff, and marking the places touched. The distance between those marks was then bisected, which gave the situation for the middle of the lamp.

In a very early stage of the business it was found, that the effects of heat and cold on the limb of the instrument were likely to produce the greatest errors; for if the canvas partitions, forming the sides of the observatory, were open to windward, streams of air passing unequally over the surface of it would cause such sudden effects, that little dependance could be placed on any observations made with the instrument in such a state. To avoid this; it was the constant practice when the wind blew with any degree of violence, to prevent the admission of it as much as possible, by keeping up the walls of the external tent, leaving only a sufficient opening for the discovery of the lamp or light; and at other times when the wind blew moderately, and a greater difference appeared in the readings of the opposite microscopes, than an error in division might be supposed to produce, the walls of the external tent were entirely thrown down, and the instrument kept in an equal temperature by the admission of air on all sides.

In taking the angles, it was a general rule for some person to keep his eye at one of the microscopes, and bisect the dot, as the observer moved the limb with the finger-screw of the

clamp. This precaution is very necessary when white lights are used, for should there be a mistake in reading off an angle, when several are taken from the same lamp as the permanent object, it sometimes may prove troublesome to rectify the error, without sending other white lights to the stations. We found that to be the case at Ditchling Beacon, when only one person happened to be at the instrument, and a reading was set down 10″ wrong. A similar circumstance occurred at Brightling. For these reasons, lamps are greatly preferable to white lights, when the distances are not too great.

As the instrument was sometimes found to sink on the axis, which was partly owing to wear by the constant use of it, and the screws of the centre work loosening a little by the shaking of the carriage; whenever it came to a new station, the opposite points were examined; and if it was found that the circle had fallen, which would be shown by the runs of the micrometers, it was raised a little, and the microscopes re-adjusted.

At the different stations, after the observations had been made, large stones, from a foot and a half to two feet square, were sunk in the ground, generally two feet under the surface, having a hole of an inch square made in each of them, whose centre was the precise point of the station.

ART IV. *Angles taken in the Year* 1792.

At Hanger Hill.

Between

	°	′	″	Mean. ″
Shooter's Hill and Banstead	62	18	49,5	
			49,75	50,25
			51,5	

Between	°	′	″	Mean. ″
St. Ann's Hill and Banstead -	62	40	34,75 34,75 35,75	35
St. Ann's Hill and Hampton Poor House	24	39	16,5 16,5 17,75	17

At St. Ann's Hill.

	°	′	″	Mean. ″
King's Arbour and Hampton Poor House	44	18	51,5 52 53,25	52,25
Hind Head and Banstead -	90	43	33	
Banstead and Hanger Hill -	63	56	46,5 47 47,5	47
Leith Hill and Banstead -	44	3	3	
Leith Hill and Hind Head -	46	40	30,5	
Bagshot Heath and Banstead	144	39	26	
Hanger Hill and Hampton Poor House	25	17	40,5 41	40,75
Banstead and Hampton Poor House	38	39	6 6,25	6
Shooter's Hill and Hanger Hill	30	28	17 17	17

At King's Arbour.

	°	′	″	Mean. ″
St. Ann's Hill and Hampton Poor House	74	14	35 35,75	35,25
St. Ann's Hill and Banstead -	71	46	23 23,5	23,25

At Hampton Poor House.

	°	′	″	Mean. ″
St. Ann's Hill and King's Arbour	61	26	33,5 35,5	34,5

Between	°	′	″	Mean. ″
St. Ann's Hill and Hanger Hill -	130	3	3	3,25
			3,5	
At Banstead.				
Shooter's Hill and Botley Hill -	57	11	36	36
			36,25	
St. Ann's Hill and Hanger Hill	53	22	39,5	39,75
			40	
Botley Hill and Leith Hill -	108	50	47,5	49
			48,25	
			51,5	
Leith Hill and St. Ann's Hill -	77	37	33,75	35,5
			37,25	
King's Arbour and St. Ann's Hill -	25	15	42	42,25
			42,5	
			42,5	
Shooter's Hill and Hanger Hill -	62	57	20	22
			24	
Leith Hill and Shooter's Hill -	166	2	23,5	23,5
			23,5	
At Leith Hill.				
Banstead and Botley Hill -	31	21	8	10
			12	
Banstead and Hind Head - -	140	28	13,5	13,5
			13,75	
Hind Head and Chanctonbury Ring -	72	56	49,5	50,25
			51,25	
Ditchling Beacon and Chanctonbury Ring	32	43	56,25	57,5
			58,5	
St. Ann's Hill and Hind Head -	82	8	51	
Hind Head and Crowborough Beacon	143	57	47,5	47,5
			47,75	
Hind Head and Bagshot Heath -	56	37	29,5	

Between	°	′	″	Mean. ″
Shooter's Hill and Nettlebed -	86	23	24	25,75
			27,5	
Hind Head and Shooter's Hill -	148	28	30	32,5
			32,5	
			33,25	
			33,25	
			33,75	

At Shooter's Hill.

Botley Hill and Banstead - -	37	8	25,75	
Banstead and Blackheath -	42	52	48,5	
Hanger Hill and Blackheath -	11	51	1,25	
Leith Hill and Blackheath -	48	50	6	6,75
			7,5	
Nettlebed and Blackheath - -	7	58	25,5	
Nettlebed and Leith Hill -	56	48	30	31
			32	
St. Ann's Hill and Blackheath -	12	41	15,75	16,5
			17,25	

At Bagshot Heath.

St. Ann's Hill and Hind Head -	101	49	23,75	
St. Ann's Hill and Leith Hill -	53	52	13,5	
Leith Hill and Hind Head - -	47	57	7	7
			7	
Nettlebed and Leith Hill -	168	32	12	13,75
			13	
			16	
Nettlebed and Highclere - -	60	10	26	24
			22	
Nettlebed and Penn Beacon -	42	50	12,25	12,5
			12,75	
Leith Hill and Highclere - -	131	17	22,5	

At Hind Head.

Between	°	′	″	Mean. ″
Nettlebed and Leith Hill - -	94	9	57,5 57,75	57,5
Nettlebed and Bagshot Heath -	18	44	31,25 33,25	32,25
Leith Hill and St. Ann's Hill - -	51	10	38 41,5	39,75
Leith Hill and Rook's Hill -	111	57	2 4,5	3,25
Leith Hill and Butser Hill -	156	25	10,75 8,25	9,5
Leith Hill and Chanctonbury Ring	61	52	25,5	
Chanctonbury Ring and Rook's Hill	50	4	37	
Nettlebed and Highclere - -	43	8 9	58,5 0,5	59,5

At Rook's Hill.

	°	′	″	Mean.
Chanctonbury Ring and Butser Hill	147	49	26,5	
Chanctonbury Ring and Hind Head -	82	42	45 46,5	45,75
Chanctonbury Ring and Dunnose -	137	16	48,5	
Chanctonbury Ring and Beachy Head	14	17	34	
Chanctonbury Ring and Motteston Down	153	1	1	

At Butser Hill.

	°	′	″	Mean.
Rook's Hill and Hind Head - -	70	25	13 14,5	13,75
Rook's Hill and Dunnose - -	80	21	58	
Rook's Hill and Motteston Down -	101	7	7 9	8
Rook's Hill and Highclere -	154	56	56 58,5	57,25
Rook's Hill and Dean Hill - -	156	34	14 *dubious.*	

At Chanctonbury Ring.

Between	°	′	″	Mean. ″
Rook's Hill and Leith Hill - -	92	23	25 25,25	25
Rook's Hill and Hind Head -	47	12	37 39,25	38
Hind Head and Leith Hill - -	45	10	46	
Rook's Hill and Ditchling Beacon -	179	8	4 8	6

ART. V. *Further Particulars respecting the Operations of the Year* 1792.

Excepting the stations Nine Barrow Down, Black Down, Wingreen, Long Knoll near Maiden Bradley, Beacon Hill, Inkpin Beacon, with those about the base of verification, all the stations which constitute the series hereafter given, were selected this year.

From an opinion which we entertain, that triangles, whose sides are from 12 to about 18 miles in length, are preferable for the general purposes of a survey, to those of greater dimensions, we have endeavoured to select such stations as might constitute a series of that description. In those which were chosen to the eastward of Bagshot Heath, Hind Head, and Butser Hill, we have in some degree succeeded; but, from local circumstances, we have not been equally fortunate with those to the westward. Instead of Dean Hill, it was hoped that the ground upon which *Farley Monument* stands, might have suited our purpose; but the wood to the west of the hill was found to be so high, that even with the whole stage, the

instrument would not be sufficiently elevated. There remained, therefore, no other expedient but fixing upon Dean Hill, which is the highest spot near Farley Monument. It must be also observed, that Highclere is the only situation which affords the means of carrying on the triangles from the side Bagshot Heath and Hind Head, without forming a quadrilateral.

When the instrument was at Shooter's Hill, a staff was erected on Blackheath, for the purpose of enabling us to determine the direction of the meridian with respect to Nettlebed. This, however, was not done, the weather proving too unfavourable; but as some of the stations were referred to this staff, it may be proper to observe, that on account of its being so near Shooter's Hill, a small portfire was placed in a groove cut in it, which afforded the means of taking an angle very exactly, as the light had the appearance of a bright point.

The interior stations which were selected for the use of the small instrument, were Bow Hill, near Rook's Hill; Portsdown Common, on the road to Portsmouth; and Sleep Down, near Steyning. To the first and last of these the instrument was taken, for the purpose of fixing such objects as could not be intersected from the principal stations. The points on the coast were particularly wanted, for the construction of some maps which were making for the use of the Board of Ordnance. Those places so fixed will be given hereafter; but it must be observed, that few opportunities were lost of searching for church towers, and other objects whose situations were to be determined. That the bearings of those might be taken with precision, the observations were made either in the morning or evening, when the air was free from vapour, and with-

out that quivering motion, which, in summer, it generally has in the middle of the day.

ART. VI. *Improvement in the Axis of the great Theodolite; and the Progress of the Survey in the Year* 1793.

Towards the conclusion of the last year's operation, it was found that the axis of the instrument, by the frequent use of it, was considerably worn, and which was, perhaps, increased by the motion of the carriage, as the arch could not be clamped with tightness sufficient to prevent the circle from moving within the limits of the bell-metal arms, and the upright part of the travelling case. The consequence was, that it sometimes became necessary to let the circle lower by means of the screws; and as it was found to be exceedingly difficult to turn them equally, and by a quantity which was just sufficient, an application was made to Mr. RAMSDEN to apply something to the axis, which might enable us to adjust the circle with greater ease and accuracy. Accordingly, upon the party arriving in town, the instrument was taken to his house, and left there for the winter, during which he made the desired alteration.

The progress made in the survey during the last season, determined the extent of the business for this year: and it was then imagined, that with good weather, we might be enabled to join the triangles to the eastward with those of General ROY, and likewise observe the remaining angles in the series, having first made the necessary observations at Dunnose and Beachy Head for obtaining the directions of the meridian. It had also been foreseen, that it would soon become necessary to select some spot for the measurement

of a new base, not only to verify the triangles remote from Hounslow Heath, but likewise to determine the sides of those which might be hereafter projected for the survey of the west of England. The situation which we had looked forward to, as being the only one which would afford a base line of sufficient extent, was Sedgemoor in Somersetshire, not having then imagined that any place could be found fit for the purpose to the eastward of that situation.

By maturely deliberating upon the steps to be taken for this necessary business, it soon appeared, that Sedgemoor, from its remoteness, would not suit for a base, which was intended to be applied as a test to the sides of the great triangles which were now constituted. Inquiry was therefore made after a spot which might be less exceptionable; and as information was obtained that Longham Common, near Poole in Dorsetshire, was likely to afford such a base, we examined it in the January of this year; but not finding it fit for the purpose, we proceeded to Salisbury Plain, where we found that a base line of nearly seven miles might be measured without much difficulty between Beacon Hill, near Amesbury, and the Castle of Old Sarum. With respect to the nature of the ground, as any observations concerning it will be introduced with more advantage when we treat of the particulars of the measurement, it will be only necessary to observe, that prior to determining upon the possibility of measuring it with the necessary accuracy, we considered of the errors which would be likely to creep in from the many hypotenuses which the base would consist of, and from other circumstances which the ground from its inequality might be supposed to produce.

As the principal object of this year's business was, to deter-

mine the directions of the meridians, the party left London for the Isle of Wight early in the month of March, that it might arrive at Dunnose in proper time for making the required observations. The instrument, however, was first taken to Motteston Down, for the purpose of intersecting many places whose bearings had been last year taken when the instrument was at Rook's Hill, and which were now wanted by the surveyors of the Ordnance. This station had been selected for that purpose, and was never intended to become a principal one in the series; but when the instrument was on the spot, it was considered as proper that some observations should be made to the stations which were at that time chosen. For this reason, when the time for observing the star approached, and most of the lights had been fired without our having seen them, it was not considered of consequence to remain there any longer, and the instrument was therefore taken to Dunnose.

A small staff, of about three inches diameter, was erected on Brading Down, which is about six miles from the station, for the purpose of referring the star to it; a small lamp of six inches diameter, constructed upon the same plan as the large ones, being, when made use of, buckled at the bottom of the staff.

As the best method of obtaining the direction of the meridian, is by observing the star upon each side of the pole, whence the double azimuth is nearly obtained without any correction for the star's apparent motions, every opportunity was watched, of observing it at the times of its greatest apparent eastern and western elongations. But in the unsettled season of the month of April, when almost every wind brought

a fog over the station, many days elapsed without our seeing either the star or staff; and it was on that account we continued so long at Dunnose.

As the truth of the deductions must entirely depend on the accurate determination of the directions of the meridians, the greatest care was taken in making the observations. An hour, and generally more, before the star came to its greatest elongation, the observers repaired to the tent for the purpose of getting the instrument ready. The method of adjusting it, was first by levelling it in the common way with the spirit level which hangs on the brass pins; and afterwards, by that which applies to the axis of the transit. The criterion which determined the instrument to be properly adjusted, was the bubble of the latter level remaining immoveable between its indexes, while the circle was turned round the axis.

As the star, four minutes either before or after its greatest elongation, moves only about a second in azimuth, the time was shown sufficiently near, by a good pocket watch, which was regulated as often as opportunities offered. When the star was supposed to be at its greatest elongation, the observer, if at night, brought it upon the cross wires, and bisected it, leaving equal portions of light on each side of the cross: but if it was in the day, when the star appeared like a point, the telescope was moved in the vertical till it came near the vanishing point of the cross. At either of these times, when the observer was satisfied of the star being properly bisected, or brought into the vanishing point formed by the wires, another person who had kept his eye at the microscope, bisected the dot. The transit was then taken off, and the instrument being turned half round, and the telescope replaced, the star

was observed again. This precaution was taken to obviate the errors which might arise, from the arms of the instrument being out of the parallel with the plane of the circle, owing to any imperfections in the position of the Ys, on which the transit rested. It was, however, seldom found, that a greater difference subsisted between the readings of the opposite microscopes, than what might be supposed to be the consequence of a shake in the centre, or errors in division. A mean of the readings was always taken. It must be also mentioned, that out of twenty, three and four inch white lights, which were fired at Beachy Head, only three of them were seen: but the angle between that place and the staff on Brading Down was considered, from the near agreement in the observations, to be determined with the necessary accuracy.

After the business was finished at Dunnose, the instrument was taken to Chanctonbury Ring, and Ditchling Beacon; and from the latter place to Beachy Head, in order to observe the direction of the meridian; but after placing a staff upon the high ground above Jevington, we were obliged to defer the attempt, as it was found, that owing to the effects of heat, the air was not sufficiently steady for the staff to be seen distinctly, when the star came to its greatest elongation in the day time, if the sun shone out. We therefore left Beachy Head, and proceeded to the following stations, viz. Fairlight Down, Brightling, Crowborough Beacon, and Botley Hill; from which latter place we returned in June to Beachy Head, and observed the direction of the meridian.

From this station, the party went to Dean Hill, and thence to Salisbury Plain, for the purpose of fixing on the extremities of the new base. This being done, the instrument was taken

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to Old Sarum, Four Mile Stone, Beacon Hill, Thorny Down, and Highclere, where the operations of this year terminated. But it must be observed, that owing to a strain which the clamp of the instrument sustained when at Thorney Down, no dependance could be placed on the observations which were made at Highclere. Upon this being discovered, and the season too far advanced to permit of any business being done after the instrument might be repaired, the party returned to London.

ART. VII. *Angles taken in the Year* 1793.

At Motteston Down.

Between	°	′	″	Mean. ″
Nine Barrow Down and Dunnose -	159	51	2,5 5	3,75
Butser Hill and Dunnose - -	64	41	2	
Rook's Hill and Dunnose -	44	57	46	*dubious.*

At Dunnose.

	°	′	″	Mean. ″
Dean Hill and Brading staff -	55	58	38,5 38,75	38,5
Motteston Down and Brading staff	94	49	19	
Nine Barrow Down and Brading staff	109	11	3.5 8	5,75
Butser Hill and Brading staff - -	0	15	31,5	
Rook's Hill and Brading staff -	24	28	42,5 45,5	44
Chanctonbury Ring and Brading staff	40	11	44	
Beachy Head and Brading staff -	60	42	40 42 42,25	41,5

Between	°	′	″	Mean. ″
Pole star and Brading staff Apr. 21, aftern.	24	4	21,25	
22, aftern.	24	4	22	
28, aftern.	24	4	23	
29, morn.	18	24	0	
May 5, aftern.	24	4	27,25	
12, aftern.	24	4	29,5	
13, morn.	18	23	53,25	
At Chanctonbury Ring.				
Beachy Head and Shoreham staff -	32	49	48,5 49	
Dunnose and Shoreham staff -	98	9	48,75 49,75	49,25
Rook's Hill and Shoreham staff -	125	10	2,25	
At Ditchling Beacon.				
Beachy Head and Lewes staff -	20	52	0,75	
Crowborough Beacon and Lewes staff	57	8	36	
Leith Hill and Lewes staff -	135	27	1,75 4	3
Brightling and Lewes staff - -	25	40	18,25	
Chanctonbury Ring and Lewes staff	164	1	31 32,5 33,5	32,25
At Fairlight Down.				
Brightling and Beachy Head -	59	33	1,5 2	1,75
At Brightling.				
Fairlight Down and Beachy Head	80	44	17,5 21	19,25
Crowborough Beacon and Beachy Head	102	58	14 17	15,5

Between	°	′	″	Mean. ″
Ditchling and Beachy Head -	59	29	13,5 14,5	14
At Crowborough Beacon.				
Brightling and Leith Hill -	168	27	20,5 22	21,25
Brightling and Ditchling Beacon	105	2	43 44,75	44
Brightling and Botley Hill -	145	20	27	
At Botley Hill.				
Banstead and Wrotham Hill -	152	57	2,5 6	4,25
Banstead and Shooter's Hill -	85	39	58,5	
Banstead and Crowborough Beacon	129	23	3,5	
Crowborough Beacon and Leith Hill	89	35	1	
At Beachy Head.				
Brightling and Jevington staff	46	59	33,25 34,75	34
Fairlight Down and Jevington staff	86	42	12 14	13
Rook's Hill and Jevington staff -	48	39	59	
Chanctonbury Ring and Jevington staff	40	57	21 23	22
Dunnose and Jevington staff -	69	26	51,25 52 52 53,25	52
Ditchling Beacon and Brightling -	73	58	25 28	26,5
Pole star and Jevington staff, Jul. 15 at night	30	19	54,5	
16 night	30	19	57,5	

Between		°	′	″	Mean. ″
	Jul. 26 at morn.	24	38	19	
	30 night	30	19	50,5	
	Aug. 1 morn.	24	38	20,25	
	1 night	30	19	49,5	
	2 night	30	19	50,25	
	3 morn.	24	38	23,5	
	* 11 night	30	19	47,25	
At Dean Hill.					
Beacon Hill and Highclere -		50	18	47,5	47,5
				47,5	
Beacon Hill and Wingreen - -		82	56	47	48,5
				50	
Beacon Hill and Dunnose -		160	46	8,5	
Beacon Hill and Nine Barrow Down		134	23	32,25	32,5
				32,75	
Beacon Hill and Motteston Down		174	34	56,5	57,5
				58,5	
Beacon Hill and Four Mile Stone		39	29	1,5	3,25
				5	
Beacon Hill and Butser Hill -		112	41	36	36,75
				36,5	
				38	
At Old Sarum.					
Beacon Hill and Four Mile Stone		85	58	21,5	22,5
				21,75	
				22,25	
				23,75	
Beacon Hill and Thorney Down -		48	26	3	4,5
				4,25	
				6,5	

* Many observations of the star at this station, and also at Dunnose, are rejected on account of their being made under unfavourable circumstances.

At Four Mile Stone.

Between	°	′	″	Mean. ″
Beacon Hill and Old Sarum -	70	1	45,75 47,25 48,25 49	47,5
Beacon Hill and Dean Hill - -	72	4	46,5 49,25	48
At Beacon Hill.				
Old Sarum and Four Mile Stone -	23	59	50,25 52,25	51,75
Old Sarum and Thorney Down -	33	33	23,75 24 26	24,5
Dean Hill and Four Mile Stone -	68	26	8,5 10,25 11	10
Dean Hill and Highclere -	102	45	23,5	
Thorney Down and Highclere	113	38	13,75 16,75	15,25
At Thorney Down.				
Beacon Hill and Highclere -	53	22	28,5 30	29,25
Beacon Hill and Old Sarum -	98	0	29,25 32,5	31
At Highclere.				
Dean Hill and Beacon Hill -	26	55	53 54	53,5

ART. VIII. *Particulars relating to the Operations of the Year 1794.*

The party this year took the field the fourth of March, and proceeded from London to the Isle of Purbeck, taking Butser

Hill in its way. In the observations of the year 1792, the angle at that station, between Rook's Hill and Dean Hill, is noted to be dubious. The reason which induced us to be of that opinion was, that the telescope, by some accident, was thought to have been moved after the observation of the light, and just at the time when the angle was about to be read off. As the season was then far advanced, and four lights had been fired, without our having seen more than one of them, it was determined to leave the final observation of that angle till this year. Accordingly upon our arrival at Butser Hill this second time, a lamp was sent to each of the stations, and the angle repeatedly taken, as given in the following article. The party from thence proceeded to Nine Barrow Down in the Island of Purbeck.

The reason of the business commencing so early in the season, arose from the necessity of beginning the measurement of the base on Salisbury Plain, towards the latter end of June, that it might be finished before the year should be far advanced, when the cultivated ground a mile to the northward of Old Sarum would be ploughed. It was also necessary that the angles at Wingreen and Highclere should be observed.

On account of the magnitude of the 24th and 27th triangles, the instrument was kept at the station in the Island of Purbeck till the angles between Dean Hill and the stations in the Isle of Wight were determined very accurately. It was, therefore, not till a month after the two first lights were fired, that as many observations were made as we deemed to be sufficient.

As it will answer our purpose better, to give an account of the stations which were chosen this year, for the further prosecution of the survey, in another part of this work; it remains

only to be observed, that from Nine Barrow Down the instrument was taken to Black Down, near Dorchester, and from thence to Wingreen, Highclere, and Beacon Hill; the observations which were made this year being concluded at the latter place in the beginning of June. It may, however, be mentioned, that in addition to the interior stations chosen in the year 1792, for the future use of the small instrument, three others were selected in this and the preceding season, namely, *Ramsden Hill*, near Christchurch; *Thorness* in the Isle of Wight; and *Stockbridge Hill.*

ART. IX. *Angles taken in the Year* 1794.

At Butser Hill.

Between	°	′	″	Mean. ″
Rook's Hill and Dean Hill -	156	34	19,75	20
			20,5	
			19,75	

At Nine Barrow Down.

	°	′	″	Mean. ″
Dean Hill and Wingreen -	39	34	27,75	28,75
			30,25	
			28,5	
Dean Hill and Motteston Down -	56	9	55	55,25
			55,5	
Dean Hill and Dunnose - -	61	57	20,75	20
			20	
			19	
Lulworth and Bull Barrow -	52	47	34,25	33
			32	
Dean Hill and Bull Barrow -	71	31	55,5	54,25
			56,5	
			53	
			52	

Between	°	'	"	Mean. "
Black Down and Bull Barrow -	38	58	19 19,5	19,25
At Black Down.				
Lyme and Bull Barrow -	124	32	33,25 33,25	33,25
Bull Barrow and Nine Barrow Down	56	30	18,25 19,5 18 19,75	18,75
Bull Barrow and Lulworth -	65	35	40,5 41 42,5 45,5	42,5
Lulworth and station above Chesil, in Portland -	42	3	16,25 19,75 19,75 21,75 21	19,75
Lulworth and station near Portland Light House -	52	43	49,25 51,25 53,25 53,25	51,75
Pilsden Hill and Mintern - -	66	51	19,25 21 24,75	21,75
Mintern and Bull Barrow - -	31	25	56,75 57 59	57,5
At Wingreen.				
Beacon Hill and Dean Hill - -	30	13	23,75 22 23,5	23

Between	°	′	″	Mean. ″
Dean Hill and Nine Barrow Down	88	58	45,25	46,5
			47,75	
Dean Hill and Bull Barrow -	143	28	21	23
			22	
			23,75	
			25,25	
Bull Barrow and Bradley Knoll -	96	20	39,25	37
			36,5	
			33,25	
			38,25	
			37,25	
Bradley Knoll and Beacon Hill -	89	57	40,25	37,75
			37,75	
			37,75	
			37,25	
			35	
At Highclere.				
Butser Hill and Dean Hill - -	69	8	33,5	35
			36,75	
			35	
Dean Hill and Beacon Hill - -	26	55	50,5	51,5
			52,25	
Thorney Down and Beacon Hill -	12	59	10,5	10
			9,25	
Beacon Hill and Inkpin Hill - -	56	0	29	29,75
			30,25	
			30	
Beacon Hill and White Horse Hill (near Wantage) - - -	90	28	20	20,5
			21	
Nuffield and Bagshot Heath -	46	10	17,5	18,5
			19,5	
Bagshot Heath and Hind Head - -	34	46	14,75	15,75
			15,75	
			16,75	

Between	°	′	″	Mean. ″
Butser Hill and Hind Head - -	29	12	22 22,$\frac{1}{4}$	22
At Beacon Hill.				
Dean Hill and Wingreen - -	66	49	52,25 51,75	52
Wingreen and Bradley Knoll -	32	11	44,75 44,25 43,5 40,75	43,25
Inkpin Beacon and Dean Hill -	120	28	2,25 1,25 3	2
Wingreen and St. Ann's Hill (near Devizes) - - -	106	27	9 8 7	8

ART. X. *Situations of the Stations.*

Hanger Hill. The station on this Hill is in the field to the eastward of the Tower, and within 13 feet of the eastern hedge. The Tower bears due west of the station.

Shooter's Hill. The station is in the north-west corner of the field, opposite to the Bull Tavern.

Banstead. The station is in a field belonging to Warren Farm, near the road leading to Ryegate. It is fourteen feet north of the hedge, and may be easily found, as Leith Hill and an opening between two rows of trees on Banstead Common, are in a line with the station.

Leith Hill in Surrey. The station is 32 feet from the north-east corner of the Tower, and in that direction from it.

Crowborough Beacon, Sussex. The station is about 600 feet

due south of the spot on which the beacon was formerly erected.

Brightling, Sussex. The station is about 70 feet south-west of the gate belonging to the field in which stands Brightling Windmill.

Beachy Head. Twelve yards south-west of the Signal-house. The muzzle of the gun is above the surface of the ground.

Ditchling Beacon, Sussex. The station is in the middle of a small rising, which has the appearance of having once been a Barrow.

Chanctonbury Ring, Sussex. This place is near Steyning; and the station is situated 50 feet from the ditch on the west side of the Ring.

Rook's Hill, near Goodwood, Sussex. The station is east of the Trundle, and near it.

Butser Hill, Hampshire. There is no precise way of pointing out the spot on which the instrument was placed: the general situation of it, however, may be known: it is on the middle of the hill, which is itself near, and to the northward of the Fifty-four Mile-stone on the Portsmouth road.

Dunnose, Isle of Wight. The station is 87 feet northward of Shanklin Beacon: the muzzle of the gun is above the surface of the ground.

Motteston Down, Isle of Wight. The station is on the west Barrow.

Nine Barrow Down, Isle of Purbeck. The station on the highest of the *Nine Barrows*.

Black Down in Dorsetshire. The station is 23 feet west of the North Barrow. Black Down is six miles from Dorchester, and near the village of Winterbourn.

Bull Barrow Hill, near Milton Abbey in Dorsetshire. The station is on the Barrow.

Wingreen, Dorsetshire. The hill so named, is four miles east of Shaftesbury, and the station is about 80 feet south-west of the Ring, or clump of trees.

Beacon Hill, about two miles from Amesbury, near the Andover road, Wiltshire. The station may be easily found, as there is a stone whose surface is above that of the ground, placed about 10 feet east of it.

Old Sarum. The station is south-east of the Two Mile-stone, and near it. A large stone with its surface above that of the ground, is placed 11 feet due west of the station.

Four Mile-stone, Wiltshire. The station is in the field west of the Four Mile-stone on the Devizes road, leading from Salisbury. It is on the rising which is in the middle of the field.

Thorney Down, Wiltshire. The Down is near Winterbourn, and the station to the north of the wood.

Dean Hill, Hampshire. This place is near the village of Dean, and about 6 miles east of Salisbury: the station is in the north-west corner of a field belonging to Mr. HALIDAY.

Inkpin Beacon, Wiltshire. This hill is above the village of Inkpin, and the station is in the centre of the small field circumscribed by a ditch and parapet of an ancient fortification.

Highclere, Wiltshire. The station is in the centre of the Ring on Beacon Hill, about half a mile south-east of Highclere.

Bagshot Heath. The station is on the brow of an eminence two miles north of the Golden Farmer, and directly west of the north corner of Bagshot Park.

Hind Head, Surrey. The station is near the Gibbet, being about 22 feet north-west of it.

The situations of those stations which are common to this operation and that of General Roy, are not described, the same being done in the LXXXth Volume of the Philosophical Transactions.

As it is probable that some individual will avail himself of the particulars given in this performance, by forming more correct maps of the counties over which the triangles have been carried, and who consequently may wish to visit certain of the stations, it is proper to observe, that small stakes are placed over the stones sunk in the ground, having their tops projecting a little above it. For some years there will be little difficult yin finding the stations, as the spots are well known to the neighbouring inhabitants.

SECTION THIRD.

Measurement of the Base of Verification on Salisbury Plain *with an Hundred Feet Steel Chain, in the Summer of the Year* 1794.

ART. I. *Apparatus provided for the Measurement, and the Method of using particular Articles of it.*

The apparatus with which this base was measured arrived at Beacon Hill the 25th of June, and consisted of the two steel chains, the tressels belonging to the Royal Society, and the twenty coffers which were used on Hounslow Heath, together with the pickets, iron-heads, and a few other articles, which in the beginning of this year had been made at the Tower. As it was foreseen that the truth of this measurement would, in a great degree, depend on the accurate reduction of the several hypotenuses to the plane of the horizon, an application was

made to Mr. RAMSDEN in the foregoing winter, to consider of some means by which their inclinations might be obtained. He therefore applied an arch S to the side of the transit telescope, as exhibited in Tab. XLIII. which he divided into half degrees; and opposite to this he placed a microscope T, with a moveable wire in its focus, by means of which, and the micrometer of the telescope, an angle could be taken.

On the first convenient opportunity after the arrival of the apparatus, we determined the value of any number of revolutions of the micrometer-screw in parts of a degree, by the following method.

At the distance of an hundred feet from the transit, a picket was set up, on which a dot was made with chalk, and the instrument being adjusted, was moved by the finger-screw till the edge of the micrometer-wire touched some prominent part of that mark. The wire in the focus of the microscope was then made to bisect a dot upon the arch, and the telescope moved in the vertical till the next dot was bisected, by which the instrument had described half a degree upon its axis, and the micrometer-wire was afterwards moved till it touched the same part of the chalk mark, the revolutions being counted, which were consequently equal to thirty minutes. This operation was repeatedly tried, with a picket placed from one to six hundred feet successively from the telescope, the runs of the micrometer-screw being in each case nearly the same, as indeed they ought to be according to theory.

The number of revolutions equal to 30′ was found, from a mean of these trials, to be $12\frac{10}{100}$.

Having determined this, the chains A and B were compared with each other, when they were found to have the same difference of lengths as when measured by Mr. RAMSDEN.

For the purpose of tracing out the line of the base, as Beacon Hill had a commanding view of almost the whole of it, the instrument was kept in the tent after the observations were finished: and at different times, when the air was sufficiently steady for the purpose, many points in the true direction were found by bisecting the staff erected at Old Sarum, and moving the transit in the vertical, whilst a person placed a camp-colour in the proper situation on the ground, by means of signals which were made at Beacon Hill.

As it appeared, when this spot was first selected for the measurement, that in the course of it there would be frequent necessity for changing the directions of the hypotenuses, a brass bar, of a prismatic form, had been provided, by means of which, and a plumb-line, a new direction was easily taken. The method of using them was as follows.

A picket was driven into the ground close to the handle of the chain, having its top eight or ten inches above the place where the preceding hypotenuse was to terminate, one of the register-heads, with the bar, being screwed on it. The chain was then stretched, and the silver wire, or plumb-line, made to pass through the handle, whilst the slider was moved till the wire came upon the dart, marking by this means, the termination of the hypotenuse. In order, however, to give a more perfect idea of this matter, a figure is given in Tab. XLV. where B is the bar, with the wire falling through the handle of the chain, one half of it being left out, for the purpose of showing its coincidence with the arrow on the handle.

The experience which we had obtained in the measurement of the base on Hounslow Heath, led us to discover, that some of the methods we made use of to execute particular parts of it, might have been improved. One of them was, the means

by which the heads of the pickets were placed in the plane of the base, which frequently was the cause of the planes of the register-heads being out of the direction of the hypotenuses. In this operation, however, the bottoms, as well as the tops of them, were placed in the true vertical by means of the transit-instrument, and therefore it was not difficult to bring the planes of their tops into the required position.

For the purpose of using the transit as a boning telescope, as well as an instrument for taking the angles of elevation or depression, Mr. RAMSDEN provided two mahogany boards, one of which was fastened to the register-head, and the other (furnished with levelling screws) rested upon it, the transit-instrument being placed on the latter.

The level belonging to the transit was then hung on the arms; and if the axis proved to be horizontal, which it would be if the brass heads were rightly placed, the instrument required no farther adjustment; but if that did not prove to be the case, the axis was made parallel to the horizon by the screws of the levelling-board, which were turned in contrary directions, having in the first instance been worked till within half the limits of their adjustment. By this means the axis was kept at a constant height from the brass heads.

A board with a cross piece, whose upper edge from the bottom of it was equal to the distance of the axis of the instrument from the head of the picket, was placed on another picket which had been driven till its head was at a convenient height in the plane of the base, and the transit moved in the vertical till the edge of the wire in the centre of the glass, coincided with that of the cross piece. The rest of the pickets in that hypotenuse were then driven into the ground, till their tops

were in the same right line, as discovered by the application of this board to their heads.

The method of determining the angles which the measured lines made with the plane of the horizon was as follows.

After the hypotenuse was measured, the transit-instrument with its boards were placed on the picket, and the levelling-screws moved as before described, if the axis did not happen to be horizontal. The cross board, upon which a black line was drawn whose breadth was about twice the apparent thickness of the micrometer-wire, and its distance from the bottom of it equal to that of the axis of the instrument from the register-head, was placed on another picket in the hypotenuse, having the brass head which had been before fixed on it still remaining. The telescope was then made horizontal, the index of the micrometer being placed to the *zero* on its circle, and the wire of the microscope set to bisect that dot on the arch which was nearest to the centre of the field. After this, the telescope was moved in the vertical by the finger-screw, till another dot was bisected, at the same time that the line upon the cross board appeared in the glass, by which the angle that the instrument had described on its axis, was measured in half degrees. The remaining part of the angle, or rather the fractional part of an half degree, was measured by the micrometer, the wire of which was brought from the centre of the glass to bisect the black line, and was either added to, or subtracted from, the former quantity, as the angle described by the telescope fell short of, or exceeded, that formed by the hypotenuse and the plane of the horizon.

By this method, all the angles of elevation and depression were taken. And we consider it as probable that they are

within a quarter of a minute of the truth; since the instrument was capable of being used with great accuracy, the arch having been divided by one of Mr. RAMSDEN's best workmen, and the value of one, or any number of revolutions of the micrometer-screw, had been accurately obtained. If, therefore, any considerable errors have taken place in this part of the operation, they must have arisen from the axis of the transit-instrument and the line on the cross board not being of the same height from the brass heads on which they were placed: but we think there is almost a certainty that this difference was confined to such limits as will not introduce any errors of consequence; for even supposing the register-heads were placed on the pickets so unskilfully that it became necessary to turn the screws on the levelling-board as much as they were capable of, whilst the third remained unmoved, in order to adjust the transit, the error introduced on that account would be only half a minute, even though the hypotenuse should consist of but one chain, and be inclined to the horizon eight degrees. We therefore think ourselves justified in the opinion which we entertain of these angles being determined with sufficient accuracy; since, if an error of one minute had taken place in the inclination of each hypotenuse, and those errors lay all one way, the length of the base, as hereafter given, would only be varied three inches by that circumstance.

It may, perhaps, be imagined that some small errors have arisen from the handle of the chain not lying flat upon the brass heads when the new directions have been commenced. To obviate this, precautions were always taken to drive the pickets at the termination of the hypotenuses in such a manner, that the arrow on the handle could be made to coincide

with one of the divisions near the end of the brass scale, by which any error arising from their not being exactly in the same vertical plane, was rendered so trifling as not to be worth notice.

Having now related, with as much conciseness as the subject will admit, the methods which were adopted for the execution of the most essential parts of this operation, there remain only a few other particulars to be related before we give the reduction of the base.

After as many points as were judged necessary had been fixed in the true direction, by the means heretofore described, and the chains compared with each other, the mensuration was begun, and continued without much interruption for seven weeks, when it was finished with that part of the 366th chain which terminated its apparent length.

The method taken to mark this last mentioned chain, was by cutting a small hole in the bottom of the coffer, through which a plumb-line was made to pass, the point of the plummet being brought over the end of the base, and the chain moved till it touched the wire; a slight scratch was then made with a file at the point of contact.

On the first favourable opportunity, subsequent to this conclusion of the measurement, the chains A and B were compared with each other, when it was found that the wear of the former, by the constant use of it, was only one division of the micrometer head, or $\frac{1}{260}$th of an inch. The smallness of this quantity in the measurement of a base of such great length, was doubtless owing to the pivots, and pivot holes of the joints being smoothed, and as it were polished, in the operation on Hounslow Heath; and it may also be adduced as some proof,

that the joints had not rusted while the chains remained in the Tower; but to prevent this, care had been taken to deposite them in a dry place, being afterwards frequently examined and oiled.

Thus concluded the measurement of this base, in which it is certain that great pains were taken to produce an accurate result; and we are not without hopes, that the many obstacles which offered themselves have been surmounted with success; but this is left to the decision of the candid and intelligent reader.

The following table contains the particulars of this operation. The first column showing the number of hypotenuses; the second, that of the chains in each hypotenuse; the third, the observed angles of elevation or depression given to the nearest 10″; the fourth and fifth, the perpendiculars answering to the elevations and depressions; the sixth, the reduction of the hypotenuses to the horizontal lines, or the versed sines of the elevations and depressions to the hypotenuses as *radii*; the seventh and eighth, the perpendicular distance between the termination and beginning of any two hypotenuses when a new direction was commenced above or below.

ART. II. Table of the Measurement of the Base of Verification.

Hypotenuses. No.	Chs.	Angles of Elev. or Depr. ° ′ ″	Perpendiculars. Elevation. Feet.	Depression. Feet.	Reduction. Feet.	Below. Inches.	Above. Inches.
1	1	7 52 30		13,7012	0,9431		
2	1	11 31 40		19,9843	2,0172		
3	1	10 5 0		17,5080	1,5446		
4	1	7 25 20		12,9180	0,8379		
5	1	5 41 50		9,9272	0,4940		
6	7	4 49 30		58,8788	2,4806		
7	6	4 18 40		45,1033	1,6977		
8	3	3 48 30		19,9257	0,6625	31,5	
9	3	3 13 0		16,8336	0,4727	21,5	
10	1	0 9 0		0,2618	0,0003		
11	1	2 27 30	4,2893		0,0920		
12	1	0 58 30	1,7016		0,0145		
13	3	0 5 0	0,4363		0,0003		
14	6	0 34 10		5,9631	0,0293	11,5	
15	1	3 9 10	5,4999		0,1514		
16	2	1 25 20	4,9640		0,0616		
17	2	0 24 10	1,4059		0,0049		
18	5	0 8 10		1,1878	0,0014		
19	4	0 49 10	5,7206		0,0409		
20	4	0 10 50	1,2605		0,0020		
21	3	1 19 20		6,9225	0,0799	7,0	
22	7	1 38 20		20,0201	0,2864		
23	5	1 33 40		13,6216	0,1856	5,5	
24	6	1 18 20		13,6706	0,1558	14,5	
25	1	1 34 30		2,7485	0,0378		
26	9	1 15 0		19,6334	0,2142		
27	6	1 0 50		10,6169	0,0939		
28	2	0 5 40	0,3297		0,0003		
29	3	0 49 50	4,3486		0,0315		
30	5	0 15 10	2,2059		0,0049		
31	3	0 18 20		1,5999	0,0043		
32	5	0 8 50	1,2848		0,0017	18,5	
33	3	0 53 30	4,6686		0,0363		
34	8	0 8 50	2,0556		0,0026		
35	10	0 45 10	13,1381		0,0863		
36	4	0 14 0		1,6290	0,0033		
37	5	0 52 0		7,5628	0,0572		
38	2	1 40 10		5,8266	0,0849		
39	7	0 35 30		7,2284	0,0373		
40	4	1 3 10		7,3494	0,0675		
41	3	0 33 50		2,9525	0,0145	19,25	
42	1	0 54 10	1,5756		0,0124		
43	2	1 37 0	5,6425		0,0796		

Hypotenuses. No.	Chs.	Angles of Elev. or Depr.	Perpendiculars. Elevation.	Depression.	Reduction.	Below.	Above.
		° ′ ″	Feet.	Feet.	Feet.	Inches.	Inches.
44	3	0 8 40		0,7563	0,0009		
45	3	0 50 10		4,3777	0,0319		
46	4	0 55 50		6,4962	0,0529	20,0	
47	11	0 31 40		10,1325	0,0467		
48	3	0 45 30		3,9705	0,0263		
49	3	1 18 40		6,8644	0,0785		
50	2	1 58 50		6,9121	0,1195		
51	2	3 49 30		13,3418	0,4455		
52	2	3 24 20		11,8806	0,3532	29,25	
53	2	3 20 50	11,6774		0,3412		
54	2	2 31 10	8,7917		0,1933		
55	2	1 7 0	3,8976		0,0380		24,5
56	7	0 25 40		5,2262	0,0195		
57	5	0 55 40		8,0960	0,0656		
58	2	3 2 50		10,6318	0,2828		
59	2	5 34 10		19,4104	0,9441		
60	1	2 4 50		3,6305	0,0659		
61	4	0 34 10	3,9754		0,0198	8,5	
62	2	0 51 40		3,0057	0,0225		
63	3	1 21 40		7,1261	0,0847	33,0	
64	9	3 4 30	48,2788		1,2958		29,0
65	4	2 16 10	15,8396		0,3137		28,75
66	6	0 14 20	2,5016		0,0052		
67	6	1 19 10		13,8160	0,1591		
68	3	1 56 30		10,1646	0,1722		
69	3	0 25 10	2,1962		0,0080		
70	2	0 51 10	2,9766		0,0222		
71	5	0 48 20		7,0296	0,0494		
72	4	0 35 40	4,1499		0,0215		
73	4	1 30 0	10,4708		0,1371		
74	4	1 5 20	7,6014		0,0722		17,5
75	4	0 38 50		4,5184	0,0255		6,0
76	5	1 56 30		16,9410	0,2871	42,0	
77	12	0 34 50		12,1579	0,0616		
78	7	1 8 50		14,0150	0,1403		
79	9	1 37 40		25,5656	0,3632	12,0	
80	3	1 49 40		9,5686	0,1526		
81	4	0 1 0		0,1163			
82	7	1 25 0		17,3061	0,2140		
83	4	1 46 40		12,4092	0,1925		
84	7	0 41 50		8,5180	0,0518		
85	5	0 46 20	6,7387		0,0454		
86	3	0 20 40	1,8035		0,0054		12,0
87	3	1 34 20		8,2311	0,1129		
88	3	3 7 10	16,3253		0,4445		
89	5	1 2 20	9,0655		0,0822		
90	6	0 4 20		0,7563	0,0005		
91	3	1 34 50		8,2747	0,1141	4,0	
92	3	0 21 30	1,8762		0,0059		
			218,6937	634,8222	20,9158	278,0	117,25

ART. III. *Reduction of the Base measured on Salisbury Plain, to the Temperature of 62°.*

Feet.

The overplus of the 366th chain was measured by Mr. RAMSDEN, and found to be 9,939 feet; therefore the apparent length of the base was - 36590,061

By the measurement in the Duke of Marlborough's riding-house, the chain A was found to exceed 100 feet in the temperature of 54°, by 0,11425 inches; to which adding half the wear, namely, $\frac{1}{520}$ inch, we get $\frac{0{,}11617}{12}$ feet for the excess of the chain's length above 100 feet; therefore $\frac{0{,}11617}{12} \times 365{,}9$ (chains) = 3,542 feet, is the correction for excess and wear; which add - - - - + 3,542

The sum of all the degrees shown by the thermometers, was 146051; wherefore $\overline{\frac{140651}{5} - 54° \times 365{,}9} \times \frac{0{,}0075}{12} = 5{,}232$ feet, is the correction for the mean heat in which the base was measured above 54°, the temperature to which the chains were reduced; and this add - - - - + 5,232

Hence these corrections, added to the apparent length, give - - - - 36598,835

Again, for the reduction to the temperature of 62°, *viz.* for 8° on the brass scale, we have $\frac{0{,}01237 \times 365{,}9 \times 80}{12} = 3{,}017$ feet; which subtract - - — 3,017

By the tables, the sum of the versed sines of the

hypotenuses, or the corrections for reducing them to the plane of the horizon, is 20,916 feet;
and this subtract - - - - — 20,916

36574,902

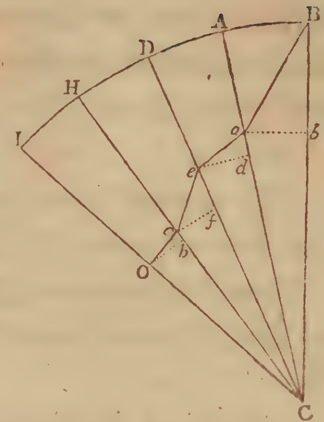
The sum of the corrections, for the reduction of the several horizontal lines from the height of the different hypotenuses above the centre of the earth, to the height of Beacon Hill above ditto, is 0,521 feet; this add - - - + 0,501

Therefore the apparent length of the base, as reduced to the level of Beacon Hill, is - feet 36575,401

But it will be hereafter shown, that the height of Beacon Hill above the sea is 690 feet nearly, and that of King's Arbour 118, and of Hampton Poor House 86 feet; therefore the height of Beacon Hill above the mean point between King's Arbour and Hampton Poor House, is 588 feet, or 98 fathoms.

Now as the base thus reduced, may be supposed to have been measured 98 fathoms farther from the centre of the earth, than that on Hounslow Heath, it must be reduced to the same level. Therefore if we take 3481794 fathoms for the mean semi-diameter, and add 98 fathoms to it, we shall get the length by this proportion, viz. 3481892 : 3481794 :: 36575,4 : 36574,4, the length of the base nearly.

With respect to that step by which the base is reduced to the level of Beacon Hill, or the correction 0,501 foot is obtained, it will be proper to show on what principle it is founded.



In the adjoining figure, let B *a*, *a e*, *e c*, and *c* O be the several hypotenuses, or measured lines; then will the sum of the corrections for their reduction to the plane of the horizon, as given in the table, exhibit that of the differences between the horizontal lines, *b a*, *d e*, *f c*, *h* O, and their corresponding hypotenuses.

Again, with the radius C B, C being the centre of the earth, describe the arc B I, or that subtended by the base, and through the terminations of the several hypotenuses, draw the lines C A, C D, C H, and C I; then will the lines B A, A D, D H and H I be those to which the horizontal ones *b a*, *d e*, *f c*, and *h* O are to be reduced, and which may therefore be done by the proportions of the lines, C *a*, C *e*, C *c*, and C O, to the constant radius C B. Upon this principle, the correction 0,501 foot has been obtained, and which is the sum of the differences between the lines *b a*, *d e*, *f c*, and *h* O, and their corresponding ones in the arc B I.

ART. IV. *Height of Beacon Hill above the Southern Extremity of the Base.*

	Feet.
The sum of the perpendiculars or elevations in the fourth column, is - -	218,6937
And of the depressions in the fifth column	634,8222
Therefore the depressions exceed the elevations	416,1285
The difference of the sums in the seventh and eighth columns, is, in feet - - -	13,35

Hence the sum is the height of the beginning of the first chain above the end of the last, namely,	429,48
But the handle of the chain at Beacon Hill was 6,7 feet above the stone, and at the other end it was 1,3 feet; therefore their difference is 5,4 feet, which subtract - - - - -	5,4
Hence the surface of the stone at Beacon Hill is higher than the surface of the stone at Old Sarum.	424,08

ART. V. *Conclusion of this Section.*

When this situation was first examined, and selected for the measurement, it was imagined that one of the extremities of the base would be fixed on somewhere near the southernmost clump of fir trees, not far from the Amesbury road, because from that spot Highclere can be seen. Those trees are near the 52d hypotenuse, and therefore about a mile from Beacon Hill; consequently, if that situation had been fixed on, the base would have been no more than six miles, and the correction for the reduction of the hypotenuses to the plane of the horizon only about 16 feet.

Now, although we think that the fixing on Beacon Hill as the northern extremity, is justified from the circumstance of a mile being added to the base, which is conceived to be more than a counterbalance for any errors which may arise from measuring down the side of a hill; there were other reasons which made it proper; a principal one is, that by selecting that spot, the base can be applied as a test to the triangles, without making the connection by means of several small ones; and another is, that if a place near the trees had been fixed on, a station must afterwards have been chosen on Beacon

Hill, in order to have a view of Long Knoll, near Maiden Bradley, and Inkpin Beacon towards Hungerford.

We shall now close this section by observing, that the measurement of this base has been almost without an alternative, since Sedgemoor, the only spot west of Salisbury proper for an operation of this kind, is about to be inclosed. Therefore had we not adopted this expedient, the triangles which may hereafter be carried on to the remote parts of the west of England, would probably have depended on the Hounslow Heath base. But we are led to believe, that this base has been measured with nearly the same accuracy which would have attended the operation, had the ground been nearly level; since there is a certainty of the angles, formed by the hypotenuses and the plane of the horizon, being determined within a minute of the truth. Now if an error of a minute in those inclinations, supposing them all to lie the same way, produce only that of three inches in the whole base, it may be concluded that 36574,4 is very nearly its true length.

SECTION FOURTH.

Calculation of the Sides of the great Triangles.

ART. I. *Of the Division of the Series into different Branches.*

In order to methodize the contents of this section, it has been considered as proper to divide the series into different branches, as the triangles of which they are composed seem naturally to resolve themselves into distinct classes.

The first branch, is that which immediately connects the

base of departure on Hounslow Heath, with that of verification on Salisbury Plain, and is bounded by the sides connecting the stations, Hanger Hill, St. Ann's Hill, Bagshot Heath, Highclere, Beacon Hill, and Four Mile-stone on the north, and on the south side by Four Mile-stone, Dean Hill, Butser Hill, Hind Head, Leith Hill, and Banstead.

The second branch, is that which proceeds from the side Hind Head and Leith Hill, to the coast of Sussex and the Isle of Wight, and principally affords the sides which will be hereafter used in finding the distance between Beachy Head and Dunnose. This branch also proceeds westward for the survey of the coast, and is bounded by the sides connecting the stations Leith Hill, Hind Head, Butser Hill, Dean Hill, and Wingreen on the north, and on the south by those connecting the stations Nine Barrow Down, Motteston Down, Dunnose, Rook's Hill, Chanctonbury Ring, and Ditchling Beacon.

The third branch, is that which proceeds from the side Hanger Hill and Banstead, to Botley Hill and Leith Hill, and from thence towards Beachy Head and Brightling, joining the series formerly projected at Botley Hill and Fairlight Down; the branch being bounded to the westward by the sides connecting the stations Hanger Hill, Banstead, Leith Hill, Ditchling Beacon, and Beachy Head.

The fourth branch, or remaining class of triangles, is that by which the distance between Beachy Head and Dunnose is obtained, and is formed by the sides connecting the stations Beachy Head, Ditchling Beacon, Chanctonbury Ring, Rook's Hill, and Dunnose.

ART. II. *Of the Selection of the Angles constituting the principal Triangles, and the Manner of reducing them for Computation.*

The angles of the several triangles, constituting the general series, are, with a very few exceptions, those arising from using the means of the several observations given in the foregoing part of this work; for although the rejecting of such as might apparently suit the purpose, would give the sums of the three angles of many of the triangles, nearer to 180 degrees *plus* the computed excess; yet as all the observations have been made with equal care, and are for the most part to be considered as of equal accuracy, it has been thought proper to select those means, as being the fairest mode of proceeding.

If the observations had been made on a sphere of known magnitude, and the angles accurately taken, the most natural method of computing the sides of the triangles from the measured bases, would be by spherical trigonometry; but if the magnitude was such, that the length of a degree of a great circle was equal to a degree of the meridian in these latitudes nearly, in order to obtain the sides true to a foot from such computation, with any facility, a table of the logarithmic sines of small arcs computed to every $\frac{1}{100}$ of a second of a degree, would be necessary, because the length of a second of a degree on the meridian is about 100 feet. As the lengths of small arcs and their chords are nearly the same (the difference in these between Beachy Head and Dunnose being less than 4 feet) it is evident this business might be performed sufficiently near the truth in any extent of a series of triangles, by plane

trigonometry, if the angles formed by the chords could be determined pretty exact. We have endeavoured to adopt this method in computing the sides of the principal triangles, in order to avoid an arbitrary correction of the observed angles, as well as that of reducing the whole extent of the triangles to a flat, which evidently would introduce erroneous results, and these in proportion as the series of triangles extended.

The length of a degree on the meridian in these latitudes being about 60874 fathoms, and that of a degree perpendicular to the meridian, about 61183; it follows, that the values of all the oblique arcs are between these extremes: now having obtained the sides of the triangles within a few feet by a rough computation, we take their values in parts of a degree, nearly as their inclinations to the meridian; this proportion, though not found on an ellipsoid, is sufficiently true for finding the values of the sides of the triangles; for in this case great accuracy is not necessary. With the sides thus determined, we compute the three angles of each triangle by spherical trigonometry; and taking twice the natural sines of half the arcs, we get, by plane trigonometry, the angles formed by the chords; then, from the differences of these angles we infer the corrections to be applied to the observed angles, to reduce them for computation: an example, however, will make this matter much plainer; for which purpose we shall take the very oblique triangle formed by the stations Beachy Head, Chanctonbury Ring, and Rook's Hill.

Arc between	Rook's Hill and B. Head	39′ 7″	chords	113785156
	Ch. Ring and B. Head	25 47		75000501
	Rook's Hill and Ch. Ring	14 0		40724320

Hence the angles by spherical trigonometry will be

		°	′	″
At Chanctonbury Ring	- -	157	59	36,29
Rook's Hill	- - - -	14	17	58,32
Beachy Head	- - -	7	42	26,56
And the angles formed by the chords	-	157	59	27,44
		14	18	3,44
		7	42	29,12

The respective differences are in the fourth column (triang. XXXIX.) In like manner the other differences in the same column have been obtained.

We have given the results to the second place in decimals, though perhaps they are true only to the nearest $\frac{1}{10}$ of a second.

In finding the angles formed by the chords, we have used Rheticus's large *Triangular Canon*, where the natural sines are given to every 10″ of the quadrant, and computed to the radius 10000000000.

It is remarked, that great accuracy in the values of the sides in the degrees, &c. is not necessary, and that this is true will be found on examination; for in the foregoing example, if the sides of the triangle be varied, so that the resulting angles are several minutes different from those found above, still the differences between the spherical and plane triangles will be very nearly the same.

When the three angles of any triangle appear to have been observed correctly, by their sum being equal to 180 degrees *plus* the computed excess, the corrections for the chord angles have been added to, or taken from them, as that correction has been negative or affirmative, and the triangle rendered fit for computation. Also, if in any triangle, where the sum has either fallen short of, or exceeded 180 degrees *plus* the com-

puted excess, one or two of the observed angles have appeared to have been determined with sufficient accuracy, as shown by the agreement of the angles obtained upon different parts of the arch; the corrections for the chord angles have been added to, or taken from them, and the remaining angle or angles considered as erroneous. In the case of one angle being supposed right, and the other two wrong, the errors have been considered equal between the latter, unless the sum of the angles round the horizon at one of the stations, has indicated, that either the whole, or the greatest part of the excess or defect, was due to a particular angle. Likewise, when any triangle has been found in excess or defect, and all the angles have appeared to be determined with equal accuracy, the corrections for the reduction to the angles formed by the chords have been first applied, and then the errors considered equal.

What is called the spherical excess in the fifth column, is computed according to the rule, page 171. Phil. Transac. Vol. LXXX. These excesses above 180° would, of course, be exactly the same as the respective sums of the differences in the fourth column, if both were not obtained from approximating rules.

It is almost unnecessary to remark, that no computations have been attempted with the chords of the sides of the lesser triangles in the principal series.

ART. III. BRANCH I. Consisting of the Triangles which connect the Base of Departure on Hounslow Heath with that of Verification on Salisbury Plain, being bounded by the Sides connecting the Stations, Hanger Hill, St. Ann's Hill, Bagshot Heath, Highclere, Beacon Hill, and Four Mile-stone on the North; and on the South Side, by those connecting the Stations Dean Hill, Butser Hill, Hind Head, Leith Hill, and Banstead.

Distance from King's Arbour to Hampton Poor House, 27404,2 Feet.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″		″	″	° ′ ″	Feet.
I.	St. Ann's Hill -	44 18 52,25				44 18 51,75	
	Hampton Poor House	61 26 34,5				61 26 33,75	
	King's Arbour -	74 14 35,25				74 14 34,5	
		180 0 2		0,21	+ 1,79		
	St. Ann's Hill from { Hampton Poor House -						37753,5
	St. Ann's Hill from { King's Arbour - -						34455,2
II.	Banstead -	25 15 42,25				25 15 41	
	King's Arbour -	71 46 23,25				71 46 22	
	St. Ann's Hill	82 57 58,25				82 57 57	
		180 0 3,75		0,62	+ 3,13		
	Banstead { King's Arbour -						80131,6*
	Banstead { St. Ann's Hill -						76687,7
III.	Hanger Hill -	24 39 16,5				24 39 16,5	
	Hampton Poor House	130 3 3,25				130 3 3,	
	St. Ann's Hill	25 17 40,75				25 17 40,5	
		180 0 0,5		0,26	+ 0,24		
	Hanger Hill { Hampton Poor House -						38670,0
	Hanger Hill { St. Ann's Hill -						69278,3*

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
IV.	Banstead -	53 22 39,75	— 0,35			53 22 39,5	
	Hanger Hill -	62 40 34,75	— 0,39			62 40 34,25	
	St. Ann's Hill	63 56 46,75	— 0,39			63 56 46,25	
		180 0 1,25		1,1	+ 0,15		
	Banstead { Hanger Hill - -						77547,4*
	Banstead { St. Ann's Hill -						76688,4

By these triangles, the distances from St. Ann's Hill to Banstead are 76687,7 feet, and 76688,4 feet; the mean of which is 76688 feet; and with this distance the sides marked with asterisks have been determined by working back.

Banstead from St. Ann's Hill, 76688,0 feet.

V.	Leith Hill -	58 19 22,5	— 0,35			58 19 22,25	
	Banstead -	77 37 35,5	— 0,44			77 37 35,	
	St. Ann's Hill	44 3 3	— 0,33			44 3 2,75	
		180 0 1		1,1	— 0,1		
	Leith Hill { Banstead - -						62655,2
	Leith Hill { St. Ann's Hill -						88019,8

Quadrilateral, formed by the Sides, St. Ann's Hill and Bagshot Heath, Bagshot Heath and Hind Head, Hind Head and Leith Hill, Leith Hill and St. Ann's Hill.

St. Ann's Hill from Leith Hill 88019,8 Feet.

VI.	Hind Head -	51 10 39,75	— 0,5			51 10 39,25	
	St. Ann's Hill	46 40 30,5	— 0,47			46 40 30,25	
	Leith Hill -	82 8 51	— 0,7			82 8 50,5	
		180 0 1,25		1,7	— 0,45		
	Hind Head { St. Ann's Hill -						111917,4*
	Hind Head { Leith Hill -						82187,8*

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
VII.	Bagshot Heath	47 57 7	— 0,53			47 57 6,5	
	Leith Hill -	56 37 29,5	— 0,53			56 37 29	
	Hind Head	75 25 25,25	— 0,63			75 25 24,5	
		180 0 1,75		1,7	+ 0,05		
		Bagshot Heath { Leith Hill - -					107115,9 *
		Bagshot Heath { Hind Head -					92425,9 *
VIII.	Bagshot Heath	53 52 14,25	— 0,16			53 52 14,25	
	Leith Hill -	25 31 21,5	— 0,2			25 31 22	
	St. Ann's Hill	100 36 23,5	— 0,6			100 36 23,75	
		179 59 59,25		0,96	— 1,71		
		Bagshot Heath from St. Ann's Hill -					46955,3 *
IX.	Bagshot Heath	101 49 22,25	— 0,62			101 49 21,75	
	Hind Head -	24 14 45,5	— 0,21			24 14 45,25	
	St. Ann's Hill	53 55 53	— 0,17			53 55 53	
		180 0 0,75		1,0	— 0,25		
		Bagshot Heath from St. Ann's Hill -					46955,4 *

Bagshot Heath from Hind Head 92425,9 Feet.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
X.	Highclere -	34 46 15,75	— 0,81			34 46 15	
	Bagshot Heath	83 20 14,25	— 1,36			83 20 14	
	Hind Head -	34 46 15,75	— 0,88			61 53 31	
		180 0 1,75		3,09	— 1,34		
		Highclere { Bagshot Heath -					142952,6 *
		Highclere { Hind Head - -					160972,2 *

No: of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XI.	Butser Hill	84 31 45,5	— 1,2			84 31 44,5	
	Hind Head	66 15 54,5	— 0,83			66 15 54,25	
	Highclere	29 12 22	— 0,72			29 12 21,25	
		180 0 2		2,7	— 0,7		
	Butser Hill { Hind Head						78905,7 *
	Butser Hill { Highclere						148031,0 *
XII.	Dean Hill	62 22 48,75	— 1,37			62 22 47	
	Butser Hill	48 28 41,5	— 1,23			48 28 40	
	Highclere	69 8 35	— 1,5			69 8 33	
		180 0 5,25		4,07	+ 1,18		
	Dean Hill { Butser Hill						156122,1 *
	Dean Hill { Highclere						125084,9 *
XIII.	Beacon Hill	102 45 23,5	— 0,9			102 45 22	
	Highclere	26 55 51,5	— 0,26			26 55 50,75	
	Dean Hill	50 18 47,5	— 0,15			50 18 47,25	
		180 0 2,5		1,3	+ 1,2		
	Beacon Hill { Highclere						98694,4
	Beacon Hill { Dean Hill						58086,3

Triangles which connect the Base of Verification with the Sides Beacon Hill and Highclere, and Beacon Hill and Dean Hill.

XIV.	Thorney Down	53 22 30				53 22 31,25	
	Highclere	12 59 10				12 59 10,75	
	Beacon Hill	113 38 16,75				113 38 18	
		179 59 56,75		0,6	— 3,85		
	Thorney Down { Highclere						112656
	Thorney Down { Beacon Hill						27634,4

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
XV.	Old Sarum Thorney Down Beacon Hill	° ′ ″ 48 26 4,5 98 0 31 33 33 24,75	″	″	″	° ′ ″ 48 26 4 5 98 0 30,75 33 33 24,75	Feet.
		180 0 0,25		0,13	+ 0,12		
	Old Sarum from Thorney Down						20416,1
XVI.	Four Mile-stone Dean Hill Beacon Hill	72 4 48 39 29 3,25 68 26 10				72 4 47,5 39 29 3 68 26 9,5	
		180 0 1,25		0,5	+ 0,75		
	Four Mile-stone { Dean Hill						56775,0
	Four Mile-stone { Beacon Hill						38818,2
XVII.	Old Sarum Four Mile-stone Beacon Hill	85 58 22,5 70 1 47,5 23 59 51,75				85 58 21,75 70 1 47 23 59 51,25	
		180 0 1,75		0,14	+ 1,61		
	Old Sarum from Four Mile-stone						15826,4

ART. IV. *The Length of the Base of* VERIFICATION *deduced from that on* Hounslow Heath, *and the foregoing Triangles.*

The base on Hounslow Heath is 27404,2 feet, which, with the four first triangles, give 76688 feet for the mean distance of St. Ann's Hill and Banstead.

That mean distance, with the 5, 6, 7, 10, 11, 12, 13, 16, and 17th triangles, will give 36574,7 feet for the base of *verification.*

If the computation be made with the 8 and 9th triangles also, and the mean distance taken between Hind Head and Bagshot, the base will be 36574,3.

And those mean distances of St. Ann's Hill and Banstead, and Hind Head and Bagshot, with the 14 and 15th triangles (excluding the 16 and 17th), will produce 36574,6, and 36574,9 respectively.

Lastly;—if the computations are carried directly from one base to the other, independent of the mean distances and the 14 and 15th triangles, the greatest and least results will be 36574,8, and 36573,8, the mean being 36574,3 feet, or about an inch short of the measurement.

Of the several ways by which the base of verification, or distance between Beacon Hill and Old Sarum is deduced, the first seems to have the preference, because the angles of the 6 and 7th triangles appear to have been observed very correctly. The results from the 14 and 15th triangles cannot be considered as very conclusive, because the angle at Highclere is so acute that a trifling error in it will vary the distance from Beacon Hill to Thorney Down very considerably: and we had some reasons for being dissatisfied with this angle, and also that in the same triangle at Thorney Down, on account of the strain in the clamp. See Sect. II. Art. VI.

Although the result of this comparison might afford some reason for supposing, that the sides of the triangles in this branch would be sufficiently near the truth, were all of them computed from the base on Hounslow Heath, yet, to approach more nearly to their correct distances, those which are marked with asterisks, have been computed with each base, and a mean of the results taken. The remaining sides have been determined by the bases in their vicinity.

ART. V. BRANCH II. Consisting of the Triangles which are bounded by the Sides connecting the Stations Leith Hill, Hind Head, Butser Hill, Dean Hill, Beacon Hill, Wingreen, Nine Barrow Down, Motteston Down, Dunnose, Rook's Hill, Chanctonbury Ring, and Ditchling Beacon.

Hind Head from Leith Hill 82187,8 Feet, mean Distance.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XVIII.	Chanctonbury Ring	45 10 46,5	— 0,44			45 10 46	
	Leith Hill -	72 56 50,25	— 0,7			72 56 49,25	
	Hind Head -	61 52 25,5	— 0,62			61 52 24,75	
		180 0 2,25		1,8	+ 0,45		
	Chanctonbury Ring { Leith Hill -						102185,7
	Chanctonbury Ring { Hind Head -						110774,4
XIX.	Chanctonbury Ring	86 44 41	— 0,62			86 44 39,75	
	Leith Hill -	32 43 57,5	— 0,39			32 43 56,5	
	Ditchling Beacon	60 31 24,75	— 0,38			60 31 23,75	
		180 0 3,25		1,5	+ 1,75		
	Chanctonbury Ring from Ditchling Beacon						63469,1
XX.	Rook's Hill -	82 42 45,75	— 0,7			82 42 45,25	
	Chanctonbury Ring	47 12 38	— 0,45			47 12 38	
	Hind Head -	50 4 37	— 0,46			50 4 36,75	
		180 0 0,75		1,6	— 0,85		
	Rook's Hill from Chanctonbury Ring -						85645,4

Butser Hill and Hind Head. Branch I. 78905,7 Feet.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
XXI.	Butser Hill -	70 25 13	— 0,39			70 25 13	
	Hind Head -	44 28 6,25	— 0,3			44 28 6,25	
	Rook's Hill -	65 6 40,75	— 0,36			65 6 40,75	
		180 0 0		1,1	— 1,1		
	Rook's Hill { Hind Head - -						81954,4
	Rook's Hill { Butser Hill -						60933,8

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXII.	Dunnose -	24 44 15,5	— 0,52			24 44 16	
	Butser Hill -	80 21 58	— 0,81			80 21 58,5	
	Rook's Hill	74 53 45	— 0,65			74 53 45,5	
		179 59 58,5		1,96	— 3,46		
	Dunnose from Rook's Hill - -						143558,9
XXIII.	Dunnose -	55 43 7	— 1,53			55 43 6,75	
	Butser Hill -	76 12 22	— 1,99			76 12 21,5	
	Dean Hill -	48 4 32,25	— 1,54			48 4 31,75	
		180 0 1,25		5,0	— 3,75		
	Dunnose { Butser Hill -						140580,4
	Dunnose { Dean Hill - -						183496,2
XXIV.	Dunnose -	53 12 27,25	— 2,03			53 12 25,5	
	Dean Hill -	64 50 19	— 2,26			64 50 16,75	
	Nine Barrow Down	61 57 19,75	— 2,22			61 57 17,75	
		180 0 6		6,5	— 0,5		
	Dunnose from Nine Barrow Down - *						188181,8
	Distance from Beacon Hill to Dean Hill, as got by the Base on Salisbury Plain - - - - - - -						58086,3
XXV.	Wingreen -	30 13 23	— 0,35			30 13 22,5	
	Beacon Hill -	66 49 52,25	— 0,39			66 49 51,5	
	Dean Hill -	82 56 47	— 0,68			82 56 46	
		180 0 2,25		1,43	+ 0,82		
	Wingreen { Beacon Hill - -						114522,4
	Wingreen { Dean Hill - -						106089

* This distance is the mean, as derived from the Salisbury Base, and from the side Butser Hill and Dean Hill.

No of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXVI.	Nine Barrow Down	39 34 28,75	— 0,82			39 34 28,25	
	Wingreen -	88 58 47,75	— 1,59			88 58 46,75	
	Dean Hill	51 26 45,5	— 0,82			51 26 45	
		180 0 2		3,24	— 1,24		
	Nine Barrow Down { Wingreen - -						130224,5
	Nine Barrow Down { Dean Hill - -						166497
XXVII.	Motteston Down	—	— 1,71			72 48 37,5	
	Nine Barrow Down	56 9 55,25	— 1,43			56 9 53,75	
	Dean Hill -	51 1 30	— 1,3			51 1 28,75	
				4,41			
	Motteston Down { Nine Barrow Down -						135489,6
	Motteston Down { Dean Hill - -						144766
XXVIII.	Motteston Down	—	— 1,61			62 39 30,5	
	Dean Hill -	61 53 20,75	— 1,64			61 53 19	
	Butser Hill -	55 27 12	— 1,47			55 27 10,5	
				4,7			
	Motteston Down from Butser Hill -						155023,4
XXIX.	Motteston Down	64 41 2	— 0,35			64 41 4	
	Butser Hill	20 45 10	— 0,43			20 45 9,5	
	Dunnose -	94 33 47,5	— 1,0			94 33 46,5	
		179 59 59,5		1,8	— 2,3		
	Motteston Down from Dunnose - -						55104,3

The four sides of the first Branch, namely; Beacon Hill and Dean Hill, Dean Hill and Butser Hill, and Butser Hill and Hind Head, have been used in the computation of the sides of this branch, because they are supposed to be nearly true: had, however,

these triangles been considered as independent of those in the first branch, and the side Hind Head and Leith Hill been used as derived from the base on Hounslow Heath, nearly the same conclusions would have taken place; for the distance between Beacon Hill and Old Sarum would in that case be 36574,2 feet, which is only two and an half inches less than the measured base. This may be considered as a proof, that the angles of the triangles forming this branch are sufficiently correct, since the series which joins the two bases by this route, is nearly an hundred and twenty miles in extent. Some little variation in that result might be produced by a different correction of the angles of the 24th triangle: but as the angle at Butser Hill must be very nearly true, the other angles cannot, on any reasonable supposition, be so corrected as to make the computed base differ from the measured one more than six inches.

ART. VI. BRANCH III. Proceeding from the Side Hanger Hill and Banstead to Botley Hill and Leith Hill, and from thence to Brightling and Beachy Head, joining the Triangles with those of the late General ROY, at Botley Hill and Fairlight Down, being bounded to the westward by the Sides connecting the Stations Hanger Hill, Banstead, Leith Hill, Ditchling Beacon, and Beachy Head.

Hanger Hill from Banstead 77547,4 Feet.

No. of triangles	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXX.	Shooter's Hill -	54 43 49,75				54 43 49,25	
	Hanger Hill -	62 18 50				62 18 49,5	
	Banstead - -	62 57 22				62 57 21,25	
		180 0 - 1,75		1,4	+ 0,35		
	Shooter's Hill { Hanger Hill - -						84596,3
	Shooter's Hill { Banstead - -						84107

No. of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXXI.	Botley Hill -	85 39 58,5				85 39 58,25	
	Shooter's Hill	37 8 25,75				37 8 25,75	
	Banstead -	57 11 36				57 11 36	
		180 0 0,25		0,9	— 0,65		
	Botley Hill { Shooter's Hill -						70894,9
	Botley Hill { Banstead - -						50927
XXXII.	Leith Hill -	31 21 10	— 0,08			31 21 9,75	
	Banstead - -	108 50 48,25	— 0,53			108 50 47,75	
	Botley Hill -	39 48 2,5	— 0,06			39 48 2,5	
		180 0 0,75		0,7	+ 0,05		
	Leith Hill from Botley Hill -						92631,5

In this triangle, using the side from Leith Hill to Banstead as got by the first branch, we find the distance between Leith Hill and Botley Hill to be 92632,9 feet; hence the mean distance is 92632,2 feet.

No. of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
XXXIII.	Crowborough Beacon	46 12 11,75	— 0,45			46 12 11,25	
	Botley Hill -	89 35 1	— 0,98			89 35 0,25	
	Leith Hill -	44 12 49	— 0,45			44 12 48,5	
		180 0 1,75		1,9	— 0,15		
	Crowborough Beacon { Botley Hill - -						89492,5
	Crowborough Beacon { Leith Hill -						128331,9
XXXIV.	Ditchling Beacon	78 18 27	— 0,91			78 18 25,5	
	Crowborough Beacon	63 24 37,25	— 0,69			63 24 36,25	
	Leith Hill -	38 16 59,75	— 0,62			38 16 58,25	
		180 0 4		2,2	+ 1,8		
	Ditchling Beacon { Leith Hill - -						117190,4
	Ditchling Beacon { Crowborough Beacon -						81192,2

No. of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.	Distances.
		° ′ ″	″	″	″	° ′ ″	Feet.
XXXV.	Brightling -	43 29 1,5	−0,16			43 29 1	
	Crowborough Beacon	105 2 44	−0,76			105 2 42	
	Ditchling Beacon	31 28 17,75	−0,22			31 28 17	
		180 0 3,25		1,14	+ 2,11		
	Brightling { Crowborough Beacon -						61597,6
	Brightling { Ditchling Beacon -						113942,3
XXXVI.	Beachy Head -	73 58 26,5	−0,77			73 58 26,5	
	Ditchling Beacon	46 32 19	−0,56			46 32 19,5	
	Brightling -	59 29 14	−0,64			59 29 14	
		179 59 59,5		2,0	− 2,5		
	Beachy Head { Ditchling - -						102132,4
	Beachy Head { Brightling - -						86048
XXXVII.	Fairlight Down	59 33 1,75	−0,39			59 33 1,75	
	Brightling -	80 44 19,25	−0,51			80 44 19,25	
	Beachy Head -	39 42 39	−0,36			39 42 39	
		180 0 0		1,28	− 1,28		
	Fairlight Down { Brightling - -						63773,1
	Fairlight Down { Beachy Head -						98513,7

ART. VII. *Comparison of the Distances from* Botley Hill *to* St. Ann's Hill, *and* Fairlight Down, *deduced from the recent Observations, and those of General* Roy *in* 1787, 1788.

The stations on St. Ann's Hill, Botley Hill, and Fairlight Down, connect our triangles with those of General Roy; and therefore the two distances from the middle station, Botley Hill, which are common to both series of triangles, afford

the readiest, and indeed almost the only means of comparing independent deductions from both operations; the triangle St. Ann's Hill, King's Arbour, Hampton Poor House excepted.

The distances from the station at the Hundred Acres to St. Ann's Hill and Botley Hill, according to General Roy (see the 4th and 9th triangles in his account) are 79211,22, and 48726,75 feet; and from the 4th, 5th, and 9th triangles it appears, that the included angle at that station is 169° 25′ 21″,25; these give 127424,3 feet for the distance of St. Ann's Hill and Botley Hill; this distance, however, is deduced from the base on Hounslow Heath, supposing it to be 27404,7 feet; but its mean length, according to both measurements, being 27404,2 feet, we shall have 27404,7 : 27404,2 : : 127424,3 : 127422 feet, for the distance of the stations from that mean length of the base.

According to our observations, the distances of St. Ann's Hill and Botley Hill from Leith Hill are 88019,8 and 92632,2 feet respectively, and the included angle for computation at Leith Hill 89° 40′ 32″; hence, from our triangles, the distance of the stations will be 127420 feet; which is 2 feet less than that from General Roy's triangles.

Before we compute the distance from Botley Hill to Fairlight Down, it will be necessary to premise, that an error has crept into General Roy's reduction of the measured base on Romney Marsh (see Phil. Trans. Vol. LXXX.); which, however, cannot be discovered without consulting his account of the measurement of the other base on Hounslow Heath. We are informed (page 131, Vol. LXXX.), that when the new points on the chain were laid off from the original points on the great plank in Mr. Ramsden's shop, Fahrenheit's ther-

mometer was at 55°*, but the temperature is omitted *when those points in the plank were transferred from the brass standard.* The "original points" must be those alluded to in the General's account of the Hounslow Heath base (Phil. Trans. Vol. LXXV. p. 403), which were fixed in the plank from the brass standard in the temperature of 63°; but it is probable that General Roy supposed them to have been transferred in 62°, and, through mistake, subtracted the sum of the two first corrections in page 131, instead of their difference, which in that case would have been the true correction for the contraction of the chain. The error however, is about 33 inches: for since the chain in the temperature of 55° was equal to 100 feet of the brass standard in that of 63°, it follows, from the table of expansions in the General's account of the Hounslow Heath base, that its length in $53^{\circ}\frac{4}{10}$ was equal to 100 feet of the brass standard in 62°; and therefore $53^{\circ}\frac{4}{10}$ is the temperature to which the measurement by the chain should be reduced. Now the apparent length being 258,36736 chains, and 68290,5 the sum of all the degrees shown by the thermometers in the table, page 134, we have $\overline{285{,}36736 \times 53\frac{4}{10} - \frac{68290{,}5}{5}} \times$,00763 inches = 12,8 inches, the contraction below $53^{\circ}\frac{4}{10}$; this, with the other corrections applied to the apparent length, give 28535 feet 8 inches, instead of 28532 feet 11 inches.

To determine the distance from Hollingbourn Hill to Fairlight Down from this base (28535,66 feet) by means of the fewest triangles, we suppose, according to General Roy (page

* That this was the temperature, appears in a great degree from various comparisons we made with the chain and the two new ones on Hounslow Heath: Sir J. Banks very obligingly favoured us with the Society's chain, for the purpose of trying its length with the new chains.

177) that the observed angle at Hollingbourn Hill, between Allington Knoll and Fairlight Down, was 48° 56′ 31″,5, and reduce it to 48° 56′ 30″ for computation; then from the 24th, 23d, and 22d triangles, and the triangle

Hollingbourn Hill	-	48°	56′	30″
Allington Knoll	-	88	25	44
Fairlight Down		42	37	46

we get 141759,6 feet for the distance of Hollingbourn Hill and Fairlight Down.

The distance of those stations as deduced from the other base (27404,7) is 141748,5 (see remarks in Vol. LXXX. p. 595); hence 27404,7 : 27404,2 : : 141748,5 : 141746 feet nearly, their distance from the mean of the measurements on Hounslow Heath; therefore the mean distance resulting from both bases is 141753 feet nearly. Now with this distance, and the 13th, 12th, and 11th triangles, we shall find the distance from Hollingbourn Hill to Botley Hill 150971 feet; and the angle at Hollingbourn Hill, between Botley Hill and Fairlight Down 88° 27′ 0″,25; these will give the distance from Botley Hill to Fairlight Down, 204275,5 feet.

To determine this line from our triangles, we have 92632,2 and 117190,4 feet for the distances of Botley Hill and Ditchling Beacon from Leith Hill; also 102132,4 and 98513,7 feet for the distances of Ditchling Beacon and Fairlight Down from Beachy Head; from these, with the included angles at Leith Hill and Beachy Head, we find Ditchling Beacon from Botley Hill 139567,4, and from Fairlight Down 167986,5 feet, and the included angle at Ditchling Beacon 82° 41′ 6″,8; hence the distance from Botley Hill to Fairlight Down will be 204276 feet nearly.

So near an agreement in a length of almost 39 miles, can only be attributed to chance.

Hence it appears, that a difference of 5 or 6 feet in about 27 miles (the distance of the stations Hollingbourn Hill and Fairlight Down), may be supposed in General ROY's deductions on account of the variations, or corrections in the bases on Hounslow Heath, and Romney Marsh; this difference, however, is too trifling to be of consequence in any of his principal conclusions.

ART. VIII. BRANCH IV. *Consisting of the nearest Triangles to the northward of* Beachy Head *and* Dunnose, *for finding the Distance between those Stations.*

No. of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.
		° ′ ″	″	″	″	° ′ ″
XXXVIII.	Dunnose -	15 43 0	+ 0,55			15 43 0,5
	Rook's Hill -	137 16 48,5	− 3,88			137 16 44,5
	Chanctonbury Ring	27 0 13	+ 1,37			27 0 15
		180 0 1,5		1,96	− 0,46	

By this triangle, using the distance from Rook's Hill to Chanctonbury Ring as found by the first branch, we get the distance between Rook's Hill and Dunnose, 143559,3 feet; but by the same branch, 143558,9 feet was found to be the distance; and if the side Butser Hill and Dean Hill be made the base, we shall get, by the 22d and 23d triangles, the distance from Rook's Hill to Dunnose 143557,1 feet: hence 143558,4, the mean of these three distances with the above triangle, give 214498,4 feet, for the distance between Dunnose and Chanctonbury Ring.

No. of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.
		° ′ ″	″	″	″	° ′ ″
XXXIX.	Beachy Head -	7 42 37	+ 2,56			7 42 40
	Rook's Hill -	14 17 33,25	+ 5,12			14 17 38
	Chanctonbury Ring	157 59 50,75	— 8,85			157 59 42
		180 0 1		1,19	— 0,19	

By this triangle, with the side Chanctonbury Ring and Rook's Hill, as found by the second branch, we get the distance between Chanctonbury Ring and Beachy Head, 157592,5 feet; and by the following triangle

XL.	Beachy Head -	13 58 29,5	+ 0,48			13 58 28
	Ditchling Beacon -	143 9 31,5	— 2,35			143 9 30
	Chanctonbury Ring	22 52 3,25	+ 0,99			22 52 2
		180 0 4,25		0,9	+ 3,35	

using the side Chanctonbury Ring and Ditchling Beacon as got by the second branch, we get another distance between Beachy Head and Chanctonbury Ring, namely, 157590,8 feet; wherefore the mean distance is 157591,6; and this, with the 39th triangle, give 239160,2 feet for the distance between Rook's Hill and Beachy Head: hence we have four principal distances, namely,

$$\text{Dunnose from} \left\{ \begin{array}{ll} \text{Rook's Hill} \quad - & 143558{,}4 \\ \text{Chanctonbury Ring} & 214498{,}4 \end{array} \right\} \text{feet.}$$

$$\text{Beachy Head from} \left\{ \begin{array}{ll} \text{Rook's Hill} \quad - & 239160{,}2 \\ \text{Chanctonbury Ring} & 157591{,}6 \end{array} \right\} \text{feet.}$$

And these sides used in the following triangles,

No. of triangles.	Names of stations.	Observed angles.	Diff.	Spherical excess.	Error.	Angles corrected for calculation.
		° ′ ″	″	″	″	° ′ ″
XLI.	Beachy Head -	20 46 53	− 0,2			20 46 52,75
	Rook's Hill -	122 59 14,5	− 7,7			122 59 8
	Dunnose -	36 13 58	+ 1,17			36 13 59,25
		180 0 5,5		6,77	− 1,27	
XLII.	Dunnose -	20 30 58	+ 0,86			20 30 58,75
	Chanctonbury Ring	130 59 37,75	− 8,77			130 59 29
	Beachy Head -	28 29 30	+ 1,92			28 29 32,25
		180 0 5,75		6,01	− 0,26	

give the four distances of Beachy Head from Dunnose, as beneath;

$$\left.\begin{array}{l}339394{,}6\\339395{,}0\\339399{,}2\\339401{,}5\end{array}\right\}\text{feet.}$$

Hence 339397,6, the mean, may be considered as very nearly the true distance.

In the correction of the angles of the triangles which compose this branch, we have been a little more particular than with the others of the series, as it is of much consequence that the distance between Beachy Head and Dunnose should not be left doubtful.

In the 42d triangle, it must be observed, that there is a defect of $\frac{1}{4}''$ nearly in the sum of the observed angles; in the 38th, about $\frac{1}{2}$ a second; and in the 41st, a defect of about $1''\frac{1}{4}$: the sum in the 39th is nearly right, but the angles of it are considered as residuary, or remaining angles; the triangle being too oblique to be admitted as a principal one in the series, though numbered and inserted as such.

Now it is evident, that if all the angles of the four triangles contained in the quadrilateral formed by the stations on Dunnose, Rook's Hill, Chanctonbury Ring, and Beachy Head, were accurately corrected for computation, the distance from Beachy Head to Dunnose would be found the same from each triangle, by making use of the side Rook's Hill and Chanctonbury Ring (which is common to the two most oblique ones): therefore, having assumed that distance, we found by computation, that if each of the above errors is supposed to be in *one angle* only of the respective triangles, these angles must be the three observed ones, namely, 28° 29′ 30″; 27° 0′ 13″; and 122° 59′ 14″,5; these are augmented accordingly, before the angles are finally corrected for computation. The angles of the 39th triangle, resulting from those of the other triangles, are

Chanctonbury Ring -		157°	59′	51″,25
Rook's Hill -	-	14	17	32,75
Beachy Head	-	7	42	37,25

before they are reduced to the angles formed by the chords.

ART. IX. *Containing the Triangles belonging to the Series which have had only two of their three Angles observed.*

Highclere and Beacon Hill 98694,4 feet.

Names of stations.	Observed angles.	Spherical excess.	Angles corrected for calculation.	Distances.
	° ′ ″		° ′ ″	Feet.
Inkpin Beacon -			106 26 52,25	
Highclere -	56 0 29,75		56 0 29,5	
Beacon Hill -	17 32 38,5		17 32 38,25	
Inkpin Beacon { Highclere				30948
Inkpin Beacon { Beacon Hill				85321

Wingreen and Beacon Hill 114522,4 feet.

Long Knoll -			57 50 39,75	
Beacon Hill -	31 11 43,25		32 11 43	
Wingreen -	89 57 37,75		89 57 37,25	
Long Knoll { Beacon Hill -				135272
Long Knoll { Wingreen -				72074

Wingreen and Nine Barrow Down 130224,5 feet.

Bull Barrow -			93 33 0,75	
Nine Barrow Down	31 57 25,25		31 57 25	
Wingreen -	54 29 25,75		54 29 34,25	
Bull Barrow { Nine Barrow Down				106212,2
Bull Barrow { Wingreen -				69058

Names of stations.	Observed angles.	Spherical excess.	Angles corrected for calculation.	Distances.
	° ′ ″		° ′ ″	Feet.
Bull Barrow -			84 31 24	
Nine Barrow Down	38 58 19,25		38 58 18,75	
Black Down -	56 30 18,5		56 30 17,25	
Black Down { Nine Barrow Down				126781,2
Black Down { Bull Barrow				80103,6

With respect to this last triangle, it must be observed, that in the future prosecution of the survey, the side Bull Barrow and Blackdown will be obtained by another method, the result of which, when combined with that given by this triangle, will afford a more accurate means of determining other distances which will hereafter depend upon it. This triangle, and likewise the rest of them in this article, are inserted here, as the distances deduced from them are supposed to be nearly true; they may possibly be of some service at present; but at a future period they will be given in a more perfect state.

ART. X. *Triangles for finding the Distance between Nettlebed and Shooter's Hill.*

Shooter's Hill from Botley Hill, 70894,9 feet.

Names of stations.	Observed angles.	Spherical excess.	Angles corrected for calculation.	Distances.
	° ′ ″	″	° ′ ″	Feet.
Leith Hill -	23 20 51		23 20 51	
Botley Hill -	125 28 1		125 28 1,25	
Shooter's Hill -	31 11 7,5		31 11 7,75	
	179 59 59,5	1,23		
Leith Hill from Shooter's Hill -				145696,2

St. Ann's Hill and Leith Hill, 88019,8 feet.

Shooter's Hill -	36 8 50,75		36 8 49,5	
St. Ann's Hill -	77 31 32,75		77 31 30,75	
Leith Hill -	66 19 41,5		66 19 39,75	
	180 0 5	2,77		
Shooter's Hill { St. Ann's Hill -				136665,5
Shooter's Hill { Leith Hill -				145698,6

Hence the mean distance between Shooter's Hill and Leith Hill is 145697,4.

Hind Head and Leith Hill, 82187,8 feet.

Names of stations.	Observed angles.	Spherical excess.	Angles corrected for calculation.	Distances.
	° ′ ″	″	° ′ ″	Feet.
Nettlebed -			23 44 58,75	
Hind Head -	94 9 57,5		94 9 56,25	
Leith Hill -	62 5 6		62 5 5	
	180 0 5	3,48		
Nettlebed { Hind Head - -				180325,4
Nettlebed { Leith Hill - -				203531,5

Then by using the sides Shooter's Hill and Leith Hill, and Nettlebed and Leith Hill, in the following triangle,

Shooter's Hill	56 48 31		56 48 29	
Leith Hill	86 23 25,75		86 23 23,25	
Nettlebed			36 48 7,75	
		6,97		

we get 242730 and 242732 feet for the distance of Shooter's Hill from Nettlebed, the mean being 242731 feet.

SECTION FIFTH.

Of the Direction of the Meridians at Dunnose and Beachy Head; and the Length of a Degree of a great Circle, perpendicular to the Meridian, in Latitude 50° 41′.

ART. I. *Of the Direction of the Meridian at Dunnose with respect to Brading Staff.*

	°	′	″
On April 28th in the afternoon, the angle between the pole star, when at its greatest apparent elongation from the meridian, and the staff, was observed - - - -	24	4	23
And on April 29th in the morning -	18	24	0
Wherefore half their sum is the angle between the meridian and Brading staff, namely -	21	14	11,5
On May 12th, in the afternoon, the angle between the star and staff was observed -	24	4	29,5
And on May 13th, in the morning -	18	23	53,25
Wherefore half their sum is the angle between the meridian and Brading staff, namely -	21	14	11,4

Hence 21° 14′ 11″,5, may be taken for the angle between the meridian and Brading staff, as determined by the double azimuths.

The apparent polar distances of the star, on those days which do not refer to corresponding observations on the opposite side of the meridian, are as follow:

	°	′	″		Azim. °	′	″
April 21st	1	47	57,2	which, with the lat. of Dunnose, *viz.* 50° 37′ 8″ nearly, give the azimuths for those days	2	50	11,2
April 22d	1	47	57,4		2	50	11,5
May 5th	1	48	0,7		2	50	16,8

	°	′	″
And these subtracted from the observed angles (see Sect. II. Art. VII.) give -	21	14	10,05
	21	14	10,5
	21	14	10,45

The mean of which is 21° 14′ 10″,3 for the angle between the meridian and the staff, which is a little more than 1″ different from that obtained by the double azimuths; we shall, however, take 21° 14′ 11″,5 for the true angle.

ART. II. *Of the Direction of the Meridian at* Beachy Head *with respect to* Jevington *Staff.*

	°	′	″
On August 1st, in the morning, the angle between the pole star and the staff was observed	24	38	20,25
And at night - - - -	30	19	49,5
Therefore half their sum is the angle between the meridian and Jevington staff, namely -	27	29	5
On August 2d, at night, the angle between the star and staff was observed - -	30	19	50,25
And on August 3d, in the morning -	24	38	23,5
Therefore half their sum is the angle between the meridian and Jevington staff, namely -	27	29	7

Hence 27° 29′ 6″, the mean by the double azimuths, may be taken as the angle between the meridian and the staff.

The apparent polar distances of the star, on those days which do not refer to corresponding observations on the opposite side of the meridian, are as follow:

		°	′	″		Azim. °	′	″
July	15th	1	48	4,6	which, with the latitude of Beachy Head, viz. 50° 44′ 25″ nearly, give the azimuths for those days -	2	50	49,4
	16th	1	48	4,4		2	50	49,1
	26th	1	48	2,9		2	50	46,7
	30th	1	48	2		2	50	45,3
Aug.	11th	1	47	59,3		2	50	41

	°	′	″
And these applied to the observed angles, give -	27	29	5,1
	27	29	8,4
	27	29	5,7
	27	29	5,2
	27	29	6,25

The mean of which is 27° 29′ 6″,1, for the angle between the meridian and Jevington staff, being the same as that obtained from a mean of the double azimuths.

ART. III. *Determination of the Length of a Degree of a great Circle, perpendicular to the Meridian, in Latitude 50° 41′.*

In Tab. XLV. fig. 1. let D and B be Dunnose and Beachy Head, and P the pole, forming the spheroidical triangle D P B; and let C and A be the staffs at Jevington and Brading Down, respectively.

	°	′	″
Now the angle at Dunnose, between the meridian and the staff, or P D A, was found by the double azimuths to be - - - -	21	14	11,5
And the angle between the staff and the station on Beachy Head, or A D B - -	60	42	41,5
Therefore their sum is the angle between the meridian and the station on Beachy Head, or P D B; which is - - -	81	56	53
Again; at Beachy Head the angle between the meridian and the staff, or P B C, was found by the double azimuths to be - - -	27	29	6
And the angle between the staff and the station on Dunnose, or C B D - - -	69	26	52
Therefore their sum is the angle between the meridian and the station on Dunnose, namely -	96	55	58

Hence, in the spheroidical triangle DPB, we have the angles PDB and PBD given.

Again. in fig. 2. let PGM be the meridian of Greenwich; then, if MB be the parallel to the perpendicular at G, Greenwich, we shall get (by Sect. VI. Art. II.) MB = 58848 feet, and GM = 269328 feet; therefore, taking 60851 fathoms for the length of the degree on the meridian, as derived from the difference of latitude between Greenwich and Paris, applied to the measured arc (see Phil. Trans. Vol. LXXX.) we get GM = 44′ 15″,26; consequently the latitude of the point M, (that of Greenwich being 51° 28′ 40″), is 50° 44′ 24″,74; and the co-lat. PM = 39° 15′ 35″,26.

With respect to the value of the arc MB, for the present purpose, it is not of consequence on what hypothesis it be obtained; but if 61173 fathoms be assumed for the length of a degree of a great circle perpendicular to the meridian at M, then MB = 9′ 37″,19, and the latitude of B, or Beachy Head, will be found = 50° 44′ 23″,71.

Again; in fig. 3. let WB be the arc of a great circle perpendicular to the meridian of Beachy Head at B, meeting that of Dunnose in W; and let DR be another arc of a great circle perpendicular to the meridian of Dunnose in D, meeting that of Beachy Head in R; then we shall have two small spheroidical triangles WBD and RDB having in each two angles given, namely, WDB = 81° 56′ 53″, and WBD = 6° 55′ 58″ in the triangle WBD; and DBR = 83° 4′ 2″, with BDR = 8° 3′ 7″ in the triangle DBR; and these reduced to the angles formed by the chords, give the following triangles for computation, namely,

$$\text{In the triangle WBD}\begin{cases} WBD = 6^\circ\ 55'\ 57'',2 \\ WDB = 81\ \ 56\ \ 52,4 \\ DWB = 91\ \ \ 7\ \ 10,4 \end{cases}$$

$$\text{And in the triangle BDR}\begin{cases} BDR = 8\ \ \ 3\ \ \ 6 \\ DBR = 83\ \ \ 4\ \ \ 1 \\ DRB = 88\ \ 52\ \ 53 \end{cases}$$

In which it must be noted, that the reduced angles are given to the nearest $\frac{1}{4}''$.

Now the chord of the arc BD, or the distance between Beachy Head and Dunnose, is 339397,6 feet (vide Sect. IV. Art. VIII.), which used in the

Triangle WBD gives - $\begin{cases} BW = 336115,6 \text{ feet} \\ DW = 40973,4 \text{ feet} \end{cases}$ and the triangle BDR - $\begin{cases} DR = 336980 \text{ feet} \\ BR = 47547,1 \text{ feet.} \end{cases}$

Again; let BL and DE be the parallels of latitude of Beachy Head and Dunnose, meeting the meridians in L and E: then, to find LW and ER we have two small triangles which may be considered as plane ones, namely, LBW and EDR, in which the angles at W and R are given, nearly.

Now the excess of the three angles above 180° in the triangle DBW, considered as a spherical one, is 3″ nearly; therefore the angle DWB will be 91° 7′ 12″ nearly; hence BWL = 88° 52′ 48″: consequently the angle BLW = 90° 33′ 36″, and LBW = 0° 33′ 36″. Therefore with the chord of the arc WB = 336115,6 feet, we get WL = 3285,2 feet, which added to WD, as found above, gives 44258,6 feet, for the distance between the parallels of Beachy Head and Dunnose.

Again; in the triangle BDR, considered as a spherical one, the excess is about $3''\frac{1}{2}$; hence, from the two observed angles at D and B, namely, 8° 3′ 7″, and 83° 4′ 2″, we get the third angle BRD = 88° 52′ 54″,5; and taking the triangle ERD as a plane one, the other angles will be 0° 33′ 32″,75 (EDR), and 90° 33′ 32″,75 (DER); therefore, with the chord

of the arc DR = 336980 feet, we get RE = 3288,2 feet, which taken from BR, as found above, leaves 44258,9 feet for the meridional arc, or the distance between the parallels of Beachy Head and Dunnose; which is nearly the same as before.

This method of determining the distance between the parallels is sufficiently correct; but the same conclusion may be deduced from a different principle, thus:

Let the difference of longitude, or the angle at P, be found, on any hypothesis of the earth's figure, and likewise the latitudes of Beachy Head and Dunnose; with these compute the latitudes of the points E and L; then it will be found, that the arc RE is $\frac{5}{100}''$ greater than LW; and since $\frac{1}{100}$ of a second on the meridian is nearly a foot, RE is 5 feet more than LW; hence $\frac{47547,1 - 5 + 40973,4}{2} = 44257,8$ feet is the distance between the parallels, and which is very nearly the same as found by the other method.

It seems therefore, that whatever be the value of the arch between those parallels in parts of a degree, the distance between them is obtained sufficiently near the truth; therefore, taking 60851 fathoms for the length of a degree on the meridian, we get the arch subtended by 44258,7 feet $= 7'\ 16'',4$, which subtracted from the latitude of Beachy Head, namely, $50^\circ\ 44'\ 23'',71$, leaves $50^\circ\ 37'\ 7'',31$ for the latitude of Dunnose.

We have therefore, for finding the length of the degree of a great circle perpendicular to the meridian at Beachy Head, or Dunnose, the latitudes of the two stations, and the angles which those stations make with each other and the pole.

Now it is proved in the Philosophical Transactions, Vol. LXXX. that the sum of the horizontal angles (such as PDB, PBD, fig. 1.) on a spheroid, is nearly the same as the sum of those which would be observed on a sphere, the latitudes, and

also the difference of longitude being the same on both figures. We therefore shall have recourse to that determination, and apply it to the present question.

The co-latitudes of D and B, or the arches D P and B P, are 39° 22′ 52″,69, and 39° 15′ 36″,29, therefore half their sum is 39° 19′ 14″,49, and half their difference 3′ 38″,2.

Half the sum of the angles PDB and PBD is 89° 26′ 25″,5; therefore, as *tang.* 39° 19′ 14″,49 : *tang.* 3′ 38″,2 : : *tang.* 89° 26′ 25″,5 : *tang.* 7° 31′ 57″,71, or half the difference of the angles: hence the angles for computation are 81° 54′ 27″,79, and 96° 58′ 23″,21, which, with the co-latitudes of D and B, give the difference of longitude between Beachy Head and Dunnose, or the angle DPB = 1° 26′ 47″,93.

We have now two right angled triangles, which may be considered spherical, namely, PBW, and PDR, in which the angle at the pole P is given, and likewise the sides P B and P D; therefore, using these *data*, we find the arc BW = 54′ 56″,21, and the arc DR = 55′ 4″,74.

The chords of the two perpendicular arcs are about $3\frac{1}{2}$ feet less than the arcs themselves; therefore B W = 336119,1 feet, and D R = 336983,5 feet; and by proportioning these arcs to their respective values in fathoms, we get the length of the degree of the great circle perpendicular to the meridian in the middle point between W and B = 61182,8 fathoms, and in the middle point between R and D = 61181,8 fathoms. Therefore 61182,3 fathoms is the length of a degree of the great circle perpendicular to the meridian, in latitude 50° 41′, which is nearly that of the middle point between Beachy Head and Dunnose.

If the horizontal angles, or the directions of the meridians,

have been obtained correctly, the difference of longitude between Beachy Head and Dunnose, as thus found, must be very nearly true; since the difference between the sums of the angles which would be observed on a spheroid and those on a sphere, having the latitudes and the difference of longitude the same on both figures as those places, is so small as scarcely to be computed: and it is easy to perceive, that the distance between the parallels is obtained sufficiently correct, since an error of 15 or 20 feet in that meridional arc, will vary the length of the degree of the great circle but a very small quantity.

It may possibly be imagined, that because the vertical planes at Dunnose and Beachy Head do not coincide, but intersect each other in the right line joining these stations, neither of the two included arcs is the proper distance between them, and that the nearest distance on the surface must fall between these arcs; but it is easy to show, that in the present case, the difference must be almost insensible.

In fig. 4, let B be Beachy Head, and E B P its meridian, and N and M, the points where the verticals from Beachy Head and Dunnose respectively meet the axis P P.

Now it is known, that if the planes of two circles cut each other, the angle of inclination is that formed by their diameters drawn through the middle of the chord, which is the line of intersection. Therefore, if we draw B M, and also conceive D to be Dunnose, and E P its meridian, and join D N; it is evident, that either of the angles N B M, N D M will be the inclination of the planes very nearly, because of the short distance between the stations, and their small difference in latitude. In the ellipsoid we have adopted, the distance M N

is about 62 fathoms, and hence the angle N B M, or N D M, will be found between 2 and 3″. The value of the arc between the stations is about 55′ 30″, and its length 339401 feet; hence the versed sine of half the arc will be 685 feet nearly; now, suppose the versed sines to form an angle of 3″, the greatest distance of the vertical planes on the earth's surface between the stations, will be but about $\frac{1}{10}$ of an inch.

It may also be remarked, that the inclination here determined, is the angle in which the vertical plane at one station cuts the vertical at the other; and therefore no sensible variation can arise in the horizontal angles, on account of the different heights of the stations.

If the figure of the earth be that of an ellipsoid, (fig. 5.) then B R, which is perpendicular to the surface at the point B, is the radius of curvature of the great circle, perpendicular to the meridian at that point; therefore the length of a degree of longitude is obtained by the proportion of the radius to the cosine of the latitude. Thus at Beachy Head, where the length of the degree of a great circle is 61183 fathoms nearly, we have this proportion; *rad.* : *cosine* 50° 44′ 24″ : : 61183 : 38718 fathoms, for the length of the degree of longitude. And at Dunnose, as *rad.* : *cosine* 50° 37′ 7″ : : 61182 : 38818 fathoms for the length of the degree of longitude, being about 100 different from the former. But nearly the same conclusions may be otherwise deduced; for the chords of the parallels may be found from the small triangles B W L and D E R, (fig. 3.) and these, when augmented by the differences between them and the arcs, give the length of the degree of longitude at Beachy Head 38719 fathoms, and Dunnose 38819 fathoms.

ART. IV. PROBLEM.

Having given the length of a degree of a great circle perpendicular to the meridian, in the latitude whose tangent is t, and cosine s, and likewise the length of a degree upon the meridian, to find the diameters of the earth, supposing it an ellipsoid.

In fig. 5. let A P A P be the elliptical meridian, passing through the point B, the tangent of its latitude being t, and cosine s; and put A C = T, C P = C, D = the length of the degree of the great circle, d = that of the degree upon the meridian, and r = 57°,29 &c. the degrees in radius. Then, if B F, and A F be the ordinate and abscissa to the point B;

$$FC = \frac{T^2}{\sqrt{T^2 + t^2C^2}},$$

And $\begin{cases} rD = \dfrac{T^2}{s\sqrt{T^2 + t^2C^2}} = \text{B R, the radius of curvature of the great circle,} \\ rd = \dfrac{C^2T^2}{s\sqrt{\overline{T^2 + t^2C^2}}^{\,3}}, \text{ the radius of curvature of the meridional degree.} \end{cases}$

These equations give $DC^2 = ds^2 . \overline{T^2 + t^2C^2}$; hence $C = sT\sqrt{\frac{d}{D - dt^2s^2}}$; therefore $C : T :: \sqrt{d} : \sqrt{D + \overline{D-d}\,.\,t^2}$, which call as $1 : m$; then $rD = \frac{m^2C}{s\sqrt{m^2+t^2}}$; and $C = \frac{srD\sqrt{m^2+t^2}}{m^2}$; therefore T may readily be found.

ART. V. Table, containing a Comparison between the Degrees upon the Meridian, which have been measured in different Latitudes, with those computed on three Ellipsoids whose Magnitudes have been determined by *data* applied to the Conclusions derived from the foregoing Problem.

				1st. Ellipsoid.		2d. Ellipsoid.		3d. Ellipsoid.	
Deg. on meridian in lat. 50° 41′ -				60851 fath.		60870		60851	
Deg. perp. to meridian -				61182		61182		61191	
	Lat. °	′	Measured Fath.	Computed.	Diff.	Computed.	Diff.	Computed.	Diff.
Bouguer, &c. - -	0	0	60482	60122	—360	60183	—299	60103	—379
Mason and Dixon -	39	12	60628	60607	— 21	60640	+ 12	60600	— 28
Boscovich, &c.	43	0	60725	60687	— 38	60716	— 9	60683	— 42
Cassini - -	45	0	60778	60730	— 48	60756	— 22	60727	— 51
Leisganig -	48	43	60839	60806	— 30	60831	— 8	60808	— 31
Betw. Green. and Paris	51	41	60851	60851	0	60870	+ 19	60851	0
Maupertuis, &c. -	60	20	61194	61148	— 46	61150	— 44	61156	— 38

The contents of the above table are computed from the *data* expressed in the different columns at top. In the third column, 60851 fathoms is nearly the length of the degree upon the meridian, as derived by the application of the measured arc between Greenwich and Paris to the difference of latitude, namely, 2° 38′ 26″. The fifth, contains the degrees on an ellipsoid, computed from a different length of a degree upon the meridian in lat. 50° 41′, in order to show how far the varying the length of that degree, will affect the comparison between the measured and computed degrees on the first ellipsoid: and those in the seventh are determined by using 60851 fathoms for the degree upon the meridian, and 61191 fathoms for that of the great circle perpendicular to it; which last degree is obtained by taking the angle at Dunnose, equal to 81° 56′ 53″,5, instead of 81° 56′ 53″.

Now this comparison between the measured and computed degrees, sufficiently proves that the earth is not an ellipsoid,

since the differences are, excepting two instances, constantly *minus*; this, however, presupposes that the degree of the great circle perpendicular to the meridian in lat. 50° 41′, as we have found it, and likewise the degree upon the meridian arising from the measured arc between Greenwich and Paris, and their difference in latitude, are nearly right. Also, were it of Mr. Bouguer's figure, the degree of a great circle in lat. 50° 41′ would be 61270 fathoms, which is 88 fathoms greater than we have derived it; we may therefore safely infer, that his hypothesis is more ingenious than true; since it cannot be supposed that the degree, resulting from these observations, is 88 fathoms in defect; but whether the earth be a figure formed by the revolution of a meridian round its axis, upon which the length of the degrees increase according to any law, or one whose meridians are formed by the combination of many different curves, it appears to be certain, that we may consider 61182 fathoms as nearly the length of a degree of a great circle, in latitude 50° 41′, by which we are enabled to settle the longitudes of those places whose situations have been determined in this operation.

The length of the degree, as given by General Roy, from the directions of the meridians at Botley Hill and Goudhurst, is 61248 fathoms, which is 66 fathoms different from this result: but this is not to be considered as extraordinary, since the distance between those places is not more than 23 miles, and the direction very oblique to the meridian. It is an indispensable requisite, that the stations chosen for this purpose be nearly east and west; because if both places were on the same parallel of latitude, the horizontal angles would give the difference of longitude, without adverting to the principle of

the sums of the angles on a sphere and a spheroid being nearly equal, when the places on each have corresponding latitudes, and the same difference of longitude.

Was a degree of a great circle perpendicular to the meridian measured in some place remote from the latitude of 50° 41′, the diameters of the earth, supposing it an ellipsoid, might be determined; for if l = the length of a degree of a great circle perpendicular to the meridian, in the latitude whose sine is s and cosine c, and L = the length of the degree in lat. 50° 41′, a and b being the sine and cosine of that latitude; then will the ratio of the axes be that of $\sqrt{l^2 c^2 - L^2 b^2} : \sqrt{L^2 a^2 - l^2 s^2}$. It is therefore, much to be wished, that such measurements were made in the northern part of Russia, and in the south of France, where the methods we have taken to measure this degree would also be applicable.

Having given the length of a degree of what may be considered a great circle upon the earth's surface, as deduced from the observations which have been made at Beachy Head and Dunnose, and likewise drawn such conclusions as appear to arise from it; we shall close this section with observing, that as the preserving of the points marking these stations has been considered of great consequence, his Grace the Duke of Richmond ordered an iron gun to be inserted in the ground at each of those places, which was done in the autumn of 1794. By these points being rendered permanent, the truth of this part of the operation can be examined, by re-observing the directions of the meridians; and that this may be done with the least trouble, we have preserved the points, where the staffs were erected on Brading Down and the Hill above Jevington, by inserting large stones in the ground, having a small hole in

each of them, for the purpose of denoting the exact points over which the centres of the staffs were placed; therefore the angles which we have given, as being the directions of the meridians with respect to those points, can be examined without the trouble of firing lights at Beachy Head and Dunnose. There is, however, another method of determining whether 61182 fathoms be nearly the length of a degree of a great circle upon the earth's surface; this may be done by observing the directions of the meridians at Shooter's Hill and Nettlebed, whose distance is already determined, being 242731 feet nearly. The points marking these stations are not likely to be soon removed, and can be found without difficulty.

SECTION SIXTH.

Of the Distances of the Stations from the Meridians of Greenwich, Beachy Head, *and* Dunnose; *and also from the Perpendiculars to those Meridians.*

ART. I.

In operations of this kind, the usual method of obtaining the distances of the stations from a first meridian, and from a perpendicular to that meridian, is by drawing parallels to those lines through the several stations, and then proceeding in a manner similar to that of working a traverse, after the bearings of the stations, with respect to those parallels, have been deduced from the angles of the triangles. This mode of computation might be considered as accurate, if the surface of the earth to the whole extent of the triangles was reduced to a flat: and it will not produce very erroneous results, if the series

of triangles are in a north and south, or an east and west direction nearly, provided they are on, or near the meridian, or its perpendicular; but if the triangles are considerably extended, and in all directions, the bearings of the same stations (if they may be so termed) must evidently differ, and that sometimes considerably, when obtained from different triangles. To avoid, in a great measure, the errors which might affect the conclusions derived from the present triangles, if all those distances were determined from the meridian of Greenwich only, we have considered the meridians of Beachy Head and Dunnose as first meridians also, and, with two or three exceptions, calculated the distance of each station from its nearest meridian. Bagshot Heath, Leith Hill, Ditchling Beacon, and Beachy Head, with those to the eastward, are from the meridian of Greenwich and its perpendicular; Chanctonbury Ring from the meridian of Beachy Head; and the others to the westward, from that of Dunnose.

The advantages in this mode of proceeding are very obvious; for if the directions of meridians are taken at about 80 miles distance from each other, near the southern coast, the operation may be extended to the Land's End with sufficient accuracy, without making astronomical observations for determining any intermediate latitude, as a new point of departure.

In deducing the bearings of the several stations from the meridians and their perpendiculars, we have taken the observed angles, instead of those formed by the chords, which were used in computing the sides of the principal triangles; because the latter angles at each station may be considered as constituting the vertex of a pyramid, and consequently their sum is less than 360°; but the operation of determining the distances

from the meridians, and their perpendiculars from those reduced, or pyramidical angles and the chords or sides of the triangles, independent of other *data*, would be very tedious. Great accuracy however, in these cases seems not absolutely necessary; because, if the latitudes and longitudes obtained from those distances can be depended upon to $\frac{1}{4}$ of a second (the latitude of Greenwich, from which the other latitudes are derived, being supposed exact), the conclusions will certainly be considered as sufficiently near the truth: 25 feet answers to about $\frac{1}{4}$ of a second on the meridian; and it is not difficult to show, that no uncertainty of more than about 10 feet has been introduced, even in the longest distances, in consequence of using the observed angles.

As Botley Hill is nearly south of the Observatory at Greenwich, and it may be supposed, that the distance of it from the meridian, as well as perpendicular, must be nearly true, as given in the Philosophical Transactions, it has not been considered as expedient to make this part of the operation entirely independent of General Roy's, by selecting Greenwich for a station, and observing the direction of the meridian at that place with respect to Banstead, or Shooter's Hill.

In order, therefore, to obtain the necessary *data*, when the instrument was at Botley Hill, the angle between Banstead and the station on Wrotham Hill was observed, as given in a former part of this work, and found to be 152° 57′ 4″,25; from which subtracting 79° 16′ 28″,75, the angle which Wrotham Hill makes with the parallel to the meridian of Greenwich, (Phil. Trans. Vol. LXXX. p. 601.) we get 73° 40′ 35″,5 for the inclination of Banstead to that parallel; this, with 50927 feet, the distance from Banstead to Botley Hill, give 48874,2 feet,

and 14313,5 feet; therefore 48874,2 — 171,5 = 48702,7 feet, is the distance of Banstead from the meridian of Greenwich; and 72881,3 — 14313,5 = 58567,8 feet for the distance from the perpendicular: but it must be remarked, that 171,6 and 72882,5 (see the table of general results, Phil. Trans. Vol. LXXX.) are reduced to 171,5 and 72881,3 feet, by using the proportion of 274047 : 27404,2, the results of the two measurements on Hounslow Heath.

ART. II. Table, containing the Bearings of the Stations from the Parallels to the different Meridians; and likewise their Distances from those Meridians and their Perpendiculars.

Names of stations.		Bearings.		Distance from the Meridian.	Distance from the Perpendicular.
	Meridian of Greenwich.	° ′ ″		Feet.	Feet.
	Botley Hill - -	—	—	171,5	72881,3
Botley Hill - -	Shooter's Hill - -	11 59 23	NE	14899	3533
Botley Hill - -	Banstead - -	73 40 35	NW	48702	58568
Botley Hill - -	Leith Hill - -	66 31 22	SW	84792	109784
Botley Hill - -	Crowborough Beacon	23 3 39	SE	35227	155222
Hanger Hill -	Hampton Poor House	24 11 47	SW	83084	18540
Banstead - -	Hanger Hill -	13 49 33	NW	67234	16733
Banstead - -	King's Arbour -	41 56 31	NW	102261	1036
Banstead - -	St. Ann's Hill -	67 12 13	NW	119400	28854
Crowborough Beacon	Ditchling Beacon -	47 19 22	SW	24468	210257
Leith Hill - -	Ditchling Beacon -	30 58 49	SE		
Crowborough Beacon	Brightling -	57 43 12	SE	87304	188119
Brightling - -	Fairlight Down -	61 25 47	SE	143312	218618
Ditchling Beacon -	Beachy Head -	54 39 48	SE	58848	269328
St. Ann's Hill -	Bagshot Heath -	77 27 16	SW	165234	39055
	Merid. of Beachy Head.				
Beachy Head - -	Chanctonbury Ring -	68 26 28	NW	146567	57908
	Meridian of Dunnose.				
Dunnose - -	Rook's Hill - -	45 42 55	NE	102770	100236
Dunnose - -	Butser Hill -	20 58 39	NE	50328	131263
Dunnose - -	Dean Hill - -	34 44 27	NW	104568	150786
Dunnose - -	Motteston Down	73 35 8	NW	52858	15572
Dunnose - -	Nine Barrow Down	87 56 55	NW	188061	6736
Butser Hill -	Highclere -	34 20 17	NW	33174	253495
Dean Hill - -	Highclere -	34 48 11	NE		
Dean Hill - -	Beacon Hill -	15 30 36	NW	120101	206757
Dean Hill - -	Four Mile-stone -	54 59 39	NW	151073	183355
Beacon Hill -	Thorney Down -	4 57 42	SE	117871	179212
Beacon Hill -	Old Sarum - -	28 55 42	SW	137793	174746
Dean Hill - -	Wingreen - -	81 32 37	SW	209505	135184
Nine Barrow Down	Wingreen - -	9 28 43	NW		
Rook's Hill - -	Hind Head - -	5 43 21	NE	110942	181782

ART. III. *Latitudes and Longitudes of the Stations referred to the Meridian of* Greenwich.

Names of stations.	Latitude.	Longitude. In degrees.		In time.
	° ′ ″	° ′ ″		m. s.
Shooter's Hill - -	51 28 5,1	0 3 54,5	E	0 15,6
Crowborough Beacon -	51 3 9,4	0 9 9,5	E	0 36,6
Brightling - -	50 57 43,3	0 22 39,3	E	1 30,6
Fairlight Down -	50 52 38,8	0 37 7,4	E	2 28,5
Beachy Head -	50 44 23,7	0 15 11,9	E	1 0,7
Ditchling Beacon -	50 54 7	0 6 20,5	W	0 25,3
Leith Hill - -	51 10 35,7	0 22 6,3	W	1 28,4
Banstead - -	51 19 2	0 12 44,1	W	0 50,9
Hanger Hill - -	51 31 23,7	0 17 39,6	W	1 10,6
Hampton Poor House -	51 25 35,2	0 21 46,6	W	1 27,1
King's Arbour -	51 28 47,1	0 26 50	W	1 47,3
St. Ann's Hill - -	51 23 51,4	0 31 16,6	W	2 5,1
Bagshot Heath -	51 22 7,1	0 43 15,4	W	2 53

ART. IV. *Latitude and Longitude of Chanctonbury Ring.*

	° ′ ″		m. s.
Lat. of Chanctonbury Ring -	50 53 48,5		
Long. of Beachy Head, east of Greenwich - -	0 15 11,9		
Long. of Chanctonbury Ring, west of Beachy Head -	0 37 58,8		
Long. of Chanctonbury Ring, west of Greenwich -	0 22 46,9	— in time	1 31,1

ART. V. *Latitude and Longitude of* Dunnose.

	° ′ ″
Latitude of Beachy Head -	50 44 23,7
And taking 60851 fathoms for the length of the degree upon the meridian, we get 44259 feet, the distance between the parallels of Beachy Head and Dunnose - -	0 7 16,4
	50 37 7,3 lat. of Dunnose.
The difference of long. between Beachy Head and Dunnose has been found in the preceding section -	1 26 47,9 W
And the long. of Beachy Head, east of Greenwich -	0 15 11,9 E
Therefore the long. of Dunnose, west of Greenwich, is	1 11 36 and in time 4 m. 46,4 s.

ART. VI. *Latitudes and Longitudes of the Stations referred to the Meridian of* Dunnose.

Names of stations.	Latitude. ° ′ ″	Longitude from Dunnose. ° ′ ″	Longitude West of Greenwich. In degrees. ° ′ ″	Longitude West of Greenwich. In time. m. s.
Rook's Hill -	50 53 32,5	0 26 37,7 E	0 44 58,3	2 59,9
Hind Head	51 6 56,1	0 28 53 E	0 42 43	2 50,9
Butser Hill -	50 58 40,8	0 13 3,8 E	0 58 32,2	3 54,1
Mottest.Down	50 39 40	0 13 37,8 W	1 25 13,8	5 40,9
Highclere -	51 18 46,2	0 8 40,4 W	1 20 16,4	5 21,1
Dean Hill -	51 1 50,9	0 27 10,5 W	1 38 46,5	6 35,1
Beacon Hill	51 11 4,4	0 31 18,9 W	1 42 54,9	6 51,7
Four M. stone	51 7 8,5	0 39 20,2 W	1 50 56,2	7 23,8
Thorney D.	51 6 30,2	0 30 40,8 W	1 42 16,8	6 49,1
Old Sarum -	51 5 44,7	0 35 51,5 W	1 47 27,5	7 9,9
Nine B. Down	50 38 3,5	0 48 27,8 W	2 0 3,8	8 0,3
Wingreen -	50 59 7,6	0 54 22,9 W	2 5 58,9	8 23,9

ART. VII.

The longitudes and latitudes of the stations have been computed spherically, in which we have taken the degrees upon the meridian, and of the great circle perpendicular to it, from the following table.

	Degrees on the merid. Fath.	perp. Fath.		Fathoms.
Lat. 50° 41′	60851	61182	Semi-transverse of this ellipsoid -	3491420
51 5	60859	61185	Semi-conjugate -	3468007
51 28 40″	60868	61188		

Ratio of the axes 1 : 1,006751

This ellipsoid is determined from the length of the degree obtained from the directions of the meridians at Beachy Head and Dunnose, and that upon the meridian in lat. 50° 41′, as resulting from the application of the measured arc between Greenwich and Paris, to their difference in latitude. It is not however, to be understood, that by using it, we consider the earth to be this ellipsoid: we have adopted the hypothesis, because it is obvious some small increase northward must be made to the degree upon the meridian in 50° 41′, in order to approximate to a correct scale for the computation of the latitudes. But it is evident, that any of the received hypotheses (supposing the length of the degree upon the meridian in 50° 41′ to be 60851 fathoms) would give the degrees sufficiently correct, since the principal stations, together with most of the objects fixed in this operation, are included between the parallels of 50° 37′ and 51° 28′.

In obtaining the latitudes of those places which are referred to the meridian of Greenwich, it is easy to perceive, that little error is introduced by spherical computation, since the sphe-

roidical correction for the latitude of Bagshot Heath is only about $\frac{1}{100}$ of a second. Had indeed the latitudes of the stations, which are far to the westward, been computed with distances from the meridian, and the perpendicular at Greenwich, some small errors might have been introduced, from the uncertainty of the earth's figure, and the consequent inability of computing the spheroidical correction with sufficient accuracy; but as the distance between the parallels of Beachy Head and Dunnose is obtained very nearly, the latitude of the latter station may be considered as correct as that of the former one, and consequently the places in the vicinity of Dunnose have their latitudes determined with sufficient precision.

SECTION SEVENTH.

Containing the secondary Triangles, in which two Angles only have been observed. The first seven intersected Places are intended for the small Instrument, on Account of their commanding Situations.

Beachy Head from Ditchling Beacon 102132,4 Feet.

No.	Triangles.	Angles observed.	Distances of the stations from the point intersected.	Feet.
1	Beachy Head - Ditchling Beacon *Firle Beacon* -	° ′ ″ 10 19 30 8 53 23	Firle Beacon - *Sussex*	47956 55621

Chanctonbury Ring from the support of High Down Windmill 29442 feet.

2	Chanctonbury Ring High Down Windmill *Sleep Down* -	64 54 52 79 3 33	Sleep Down -	17637 27159

Butser Hill from Rook's Hill 60933,8 feet.

3	Butser Hill - - Rook's Hill - *Bow Hill*	10 28 4 28 19 50	Bow Hill -	46150 17668
4	Butser Hill - Rook's Hill - *Portsdown Hill*	93 25 15 39 23 59	Portsdown Hill *Hampshire*	52729 82926

Dunnose from Motteston Down 55104,3 feet.

5	Dunnose - - Motteston Down *Thorness*	30 34 9 79 6 47	Thorness - *Isle of Wight*	57470 29764

Motteston Down from Nine Barrow Down 135489,6.

No.	Triangles.	Angles observed.	Distances of the stations from the point intersected.	
		° ′ ″		Feet.
6	Motteston Down - Nine Barrow Down *Ramsden Hill*	27 57 12 42 26 2	Ramsden Hill - *Hampshire*	97051 67423

Dean Hill from Beacon Hill 58086,3 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the point intersected.	
7	Dean Hill - Beacon Hill - *Stockbridge Hill*	71 10 48 51 45 47	Stockbridge Hill	54366 65515

With respect to these triangles, there is nothing to be remarked, except that the angles of the 1st and 3d, from their being very acute, were determined with considerable care: the distances however, from Firle Beacon to Ditchling Beacon, and Beachy Head, may be ascertained, when either the great or small instrument are taken to that station, by the intersection of Hurstmonceux Spire.

Triangles formed by the Intersections of Churches, Windmills, and other Objects.

Fairlight Down from Brightling 63773,1 feet.

No.	Triangles.	Angles.	Distances of the stations from the intersected objects.	
		° ′ ″		Feet.
1	Fairlight Down - Brightling - *Bexhill Church* -	48 18 18 32 6 22	Bexhill church - *Sussex*	34375 48294

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
		° ′ ″		Feet.
2	Fairlight Down - Brightling - - *Westham Church*	46 56 7 73 7 30	Westham Church	70511 53832
3	Fairlight Down - Brightling - *Pevensey Church*	46 46 20 71 21 47	Pevensey Church	68526 52694
4	Fairlight Down - Brightling - *Blackheath Windmill*	4 34 13 154 19 13	Blackheath Wind-mill -	76733 14110
5	Fairlight Down - Brightling - - *Ninefield Church*	25 26 4 40 43 54	Ninefield Church	45493 29943
6	Fairlight Down - Brightling - *Mountfield Church*	10 32 37 16 44 22	Mountfield Church	40071 25458
6*	Beachy Head - Ditchling Beacon - *Hurstmonceux Church*	76 6 36 26 40 41	Hurstmonceux Church -	47021 101668

Ditchling Beacon from Crowborough Beacon 81192,2 feet.

7	Ditchling Beacon - Crowborough Beacon *Chittingly Church*	41 17 30 58 11 13	Chittingly Church	69950 54320
8 D	Ditchling Beacon - Crowborough Beacon *Waldron Church*	13 23 46 65 34 25	Waldron Church	75316 19165

No.	Triangles.	Angles. observed.	Distances of the stations from the intersected objects.	Feet.
9	Ditchling Beacon - Crowborough Beacon *Firle Church*	67° 16′ 28″ 36 30 43	Firle Church -	49742 77110
10	Ditchling Beacon - Crowborough Beacon *Jevington Windmill*	70 32 0 58 49 56	Jevington Wind-mill -	89861 99016
11	Ditchling Beacon - Crowborough Beacon *Plumpton Church*	34 14 48 3 37 4	Plumpton Church	8347 74441
12 D	Ditchling Beacon - Crowborough Beacon *Little Horstead Church*	23 34 6 28 0 42	Little Horstead Church -	48670 41436
13	Ditchling Beacon - Crowborough Beacon *Spittal Windmill*	66 41 33 14 29 24	Spittal Windmill	20558 75458
14	Ditchling Beacon - Crowborough Beacon *Ditchling Church*	61 49 49 4 48 36	Ditchling Church	7416 77966

Chanctonbury Ring from Ditchling Beacon 63469,1 feet.

15	Chanctonbury Ring Ditchling Beacon - *Thakeham Church*	115 19 36 13 56 34	Thakeham Church	19754 74103
16	Chanctonbury Ring Ditchling Beacon - *West Grinsted Church*	66 23 40 28 9 20	West Grinsted Church -	30044 58342

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
17	Chanctonbury Ring Ditchling Beacon - *Keymer Church*	° ′ ″ 6 40 15 55 52 17	Keymer Church	59208 8309
18	Chanctonbury Ring Ditchling Beacon - *Bolney Church*	37 47 12 57 3 58	Bolney Church	53461 39029
19 D	Chanctonbury Ring Ditchling Beacon - *Slaugham Church*	50 26 25 66 41 45	Slaugham Church	65501 54985
20	Chanctonbury Ring Ditchling Beacon - *Starting House on the Race Ground near Brighthelmstone.*	23 2 19 86 0 59	Starting House	66986 26279
21	Chanctonbury Ring Ditchling Beacon - *Cuckfield Spire*	33 58 20 72 9 49	Cuckfield Spire	67789 38568
22	Chanctonbury Ring Ditchling Beacon - *Wyvelsfield Church*	20 34 55 98 0 8	Wyvelsfield Chur.	71575 25409
23	Chanctonbury Ring Ditchling Beacon - *Hurstpierpoint Church*	14 32 35 36 29 25	Hurstpierpoint Church - -	48545 20498
24 D	Chanctonbury Ring Ditchling Beacon - *Lindfield Church*	29 51 47 100 41 5	Lindfield Church	82079 41590

Chanctonbury Ring from Sleep Down, 17637 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
		° ′ ″		Feet.
25	Chanctonbury Ring Sleep Down - *Goring Church*	52 22 45 96 27 23	Goring Church	33866 26995
26	Chanctonbury Ring Sleep Down - *Southwick Church*	22 46 56 140 53 45	Southwick Church	39584 24302
27	Chanctonbury Ring Sleep Down - *Shoreham Church*	14 28 30 151 0 0	Shoreham Church	34094 17578
28	Chanctonbury Ring Sleep Down - *Brighthelmst. Church*	32 5 47 136 19 20	Brighthelmstone Church -	60672 46680
29	Chanctonbury Ring Sleep Down - *Bramber Windmill*	43 9 25 83 16 48	Bramber Wind-mill - -	21772 14995
30	Chanctonbury Ring Sleep Down - *Temple in Findon Park*	88 47 22 37 32 41	Temple in Findon Park - -	13341 21889

Chanctonbury Ring from Rook's Hill, 85645,4 feet.

31	Chanctonbury Ring Rook's Hill - - *West Tarring Church*	82 19 10 17 41 21	West Tarring Church -	26426 86189

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
		° ′ ″		Feet.
32	Chanctonbury Ring Rook's Hill - - *High Down Windmill*	56 47 5 19 30 39	High Down Windmill - -	29442 73752
33 D	Chanctonbury Ring Rook's Hill - - *Angmering Church*	45 44 35 21 55 49	Angmering Church -	34579 66312
34	Chanctonbury Ring Rook's Hill - *Sir R. Hotham's Flag-staff, near Bersted*	30 40 1 68 36 53	Sir R. Hotham's Flagstaff -	80807 44263
35	Chanctonbury Ring Rook's Hill - - *Bersted Church*	27 54 15 64 26 6	Bersted Church	77325 40115
36	Chanctonbury Ring Rook's Hill - - *Felpham Windmill*	31 22 33 60 52 32	Felpham Windmill - -	74875 44626
37 D	Chanctonbury Ring Rook's Hill - - *Clapham Church*	44 29 25 16 3 16	Clapham Church	27201 68929
38	Chanctonbury Ring Rook's Hill - - *Oving Church*	14 12 22 71 6 26	Oving Church -	81303 21089
39	Chanctonbury Ring Rook's Hill - - *Pagham Church*	27 31 18 89 41 40	Pagham Church	96306 44502

Butser Hill from Rook's Hill 60933,8 feet.

No.	Triangles.	Angles observed. ° ′ ″	Distances of the stations from the intersected objects.	Feet.
40	Butser Hill - - Rook's Hill - - *Lantern of the Vessel moored over the Ower Rocks*	26 55 45 134 6 0	Ower Rocks -	134605 84889
41	Butser Hill - - Rook's Hill - - *Selsea Church*	27 45 25 117 47 2	Selsea Church -	95276 50154
42	Butser Hill - - Rook's Hill - - *Selsea High House*	34 42 20 110 6 12	Selsea High House	99290 60199
43	Butser Hill - - Rook's Hill - - *Selsea Windmill*	34 40 45 109 9 31	Selsea Windmill	97545 58756
44	Butser Hill - - Rook's Hill - - *Cackham Tower*	43 21 26 85 21 20	Cackham Tower	77835 53613
45	Butser Hill - - Rook's Hill - - *Bosham Church*	32 2 23 74 11 15	Bosham Church	61061 33667
46	Butser Hill - - Rook's Hill - - *Princested Windmill*	43 28 50 57 30 20	Princested Windmill - -	52354 42712

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
47	Butser Hill - - Rook's Hill - - *Del Key Windmill* -	° ′ ″ 25 41 30 92 32 2	Del Key Windmill	69090 29981
48	Butser Hill - - Rook's Hill - - *West Thorney Church*	43 30 10 68 27 23	West Thorney Church -	61110 45227
49	Butser Hill - - Rook's Hill - - *South Hayling Church*	58 31 52 65 13 29	South Hayling Church -	66544 62510
50	Butser Hill - - Rook's Hill - - *Bourn Church* -	43 27 20 46 55 22	Bourn Church -	44509 41911
51	Butser Hill - - Rook's Hill - - *Flagstaff at the Watch-house near Chichester Harbour*	49 48 19 75 49 16	Flagstaff -	72681 57262
52	Butser Hill - - Rook's Hill - - *Clark's Folly* - -	69 28 9 44 0 16	Clark's Folly -	46151 62212
53	Butser Hill - - Rook's Hill - - *Portsdown Windmill*	83 38 24 41 29 17	Portsdown Windmill -	49356 74045
54	Butser Hill - - Rook's Hill - - *West Chimney on the Governor's House, Cumberland Fort.*	69 19 25 61 5 43	Cumberland Fort	70049 74803

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
55	Butser Hill - - Rook's Hill - - *South Sea Castle*	° ′ ″ 78 14 54 59 2 32	South Sea Castle	77038 87953
56	Butser Hill - - Rook's Hill - *St. Cath. Light House*	87 18 4 71 26 30	St. Catherine's Light House - *Isle of Wight*	159328 167881
57	Butser Hill - - Rook's Hill - *Sir R. Worsley's Obelisk*	84 30 52 72 3 59	Sir R. Worsley's Obelisk - *Isle of Wight*	145861 152608
58	Butser Hill - - Rook's Hill - *Ashey Down Sea Mark*	83 29 28 67 44 36	Ashey Down Sea Mark - - *Isle of Wight*	117188 125806
59	Butser Hill - - Rook's Hill - *Flagstaff of Cowes Fort*	103 12 19 50 10 44	Flagstaff, Cowes Fort - - *Isle of Wight*	104463 132415
60	Butser Hill - - Rook's Hill - *Summer House of the Horse-shoe Inn above Cowes*	100 21 10 54 17 51	Summer House -	115573 140005
61	Butser Hill - - Rook's Hill - *Needles Light House*	109 32 45 54 19 57	Needles Light House - - *Isle of Wight*	178277 206796
61*	Butser Hill - - Dean Hill - *Southampton Spire*	23 25 47 32 58 47	Southampton Spire - -	102010 74522

Rook's Hill from Bow Hill 17668 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
		° ′ ″		
62	Rook's Hill - - Bow Hill - - *Box Grove Church*	132 28 11 21 57 31	Box Grove Church	15306 30194
63	Rook's Hill - - Bow Hill - - *Portfield Windmill*	87 10 9 47 44 17	Portfield Windmill	18462 24916
64	Rook's Hill - - Bow Hill - - *North-west Chimney on Goodwood House*	116 1 21 18 38 9	Goodwood House	7938 22321
65	Rook's Hill - - Bow Hill - - *Chichester Spire*	75 29 10 59 11 56	Chichester Spire	21345 24057

Rook's Hill from Hind Head 81954,4 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
66	Rook's Hill - - Hind Head - *Sir H. Fetherstonhaugh's Tower*	57 8 41 27 50 34	Sir H. Fetherstonhaugh's Tower	38424 69110
67	Rook's Hill - - Hind Head - *Windmill near Rook's Hill*	122 22 23 2 1 34	Windmill near Rook's Hill -	3512 83887
68	Rook's Hill - - Hind Head - *Harting Windmill*	53 56 49 25 52 2	Harting Windmill - -	36328 67319

Chanctonbury Ring from Hind Head 110774,4 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
		° ′ ″		Feet.
69	Chanctonbury Ring Hind Head - *Petworth Spire*	13 43 52 16 16 36	Petworth Spire	62080 52576
70 D	Chanctonbury Ring Hind Head - *Wisborough Green Church* - -	12 50 23 11 28 10	Wisborough Green Church -	53508 59799
71	Chanctonbury Ring Hind Head - *Kirdford Church*	5 12 39 6 29 12	Kirdford Church	61725 49623
72	Chanctonbury Ring Hind Head - *Billinghurst Church*	24 48 50 16 58 51	Billinghurst Church	48543 69755
73	Chanctonbury Ring Hind Head - *Rusper Church*	59 43 43 47 42 51	Rusper Church	85901 100281

Chanctonbury Ring from Butser Hill 141003 feet.

74	Chanctonbury Ring Butser Hill - *The Earl of Egremont's Tower, near Petworth*	20 22 27 18 0 51	The Earl of Egremont's Tower	70219 79052
75 D	Chanctonbury Ring Butser Hill - *Pulborough Church*	25 12 40 8 5 46	Pulborough Church	36163 109375

Leith Hill from Hind Head 82187,7 feet.

No.	Triangles.	Angles observed. ° ′ ″	Distances of the stations from the intersected objects.	Feet.
76	Leith Hill - - Hind Head - *St. Martha's Chapel*	41 32 40 27 9 5	St. Martha's Chapel - - near Guildford	40257 58505
77	Leith Hill - - Hind Head - *Euhurst Windmill*	11 39 40 3 49 39	Euhurst Windmill	20544 62206
78	Leith Hill - - Hind Head - *Euhurst Church*	12 25 16 3 27 43	Euhurst Church	18135 64596
79	Leith Hill - - Hind Head - *Norris's Obelisk, Bagshot Heath*	51 3 46 77 52 38	Norris's Obelisk	103310 82191
80	Leith Hill - - Hind Head - *Horsham Spire*	86 36 23 28 38 34	Horsham Spire	43558 90710
81	Leith Hill - - Hind Head - *Farnham Castle*	24 34 44 101 49 30	Farnham Castle	99948 42474

Leith Hill from Ditchling Beacon 117190,4 feet.

82	Leith Hill - - Ditchling Beacon - *Beddingham Windmill*	7 38 23 152 37 54	Beddingham Windmill	159594 46153

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No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
83	Leith Hill - - Ditchling Beacon - *Firle Windmill*	° ′ ″ 9 19 46 149 13 1	Firle Windmill	163984 51942

Leith Hill from Crowborough Beacon 128331,9 feet.

84	Leith Hill - - Crowborough Beacon *West Hoathly Church*	6 9 46 10 22 53	West Hoathly Church	81212 48382

Crowborough Beacon from Fairlight Down 125303 feet.

85	Crowborough Beacon Fairlight Down - *Willington Church*	45 4 32 43 6 42	Willington Church	85678 88764

Crowborough Beacon from Brightling 61597,6 feet.

86	Crowborough Beacon Brightling - *Homehurst Church*	12 21 46 70 18 45	Homehurst Church	58474 13297
87	Crowborough Beacon Brightling - - *Hailsham Church*	37 38 24 85 39 48	Hailsham Church	73490 45009
88	Crowborough Beacon Brightling - - *Dallington Church*	6 25 16 83 32 52	Dallington Church.	61208 6889

Crowborough Beacon from Botley Hill, 89492,5 feet.

No.	Triangles.	Angles observed.			Distances of the stations from the intersected objects.	
		°	′	″		Feet.
89	Crowborough Beacon Botley Hill *East Grinsted Church*	31 24	6 17	44 45	East Grinsted Church	44729 56173
90	Crowborough Beacon Botley Hill - *Fairden Tower*	17 18	4 51	46 52	Fairden Tower	49295 44777
91	Crowborough Beacon Botley Hill - *Crowborough Chapel*	93 2	16 3	22 11	Crowborough Chapel	3220 89734
92	Crowborough Beacon Botley Hill - *Rotherfield Spire*	121 7	34 42	38 43	Rotherfield Spire	15517 98509
93	Crowborough Beacon Botley Hill - *Mayfield Spire*	137 9	42 35	2 19	Mayfield Spire	27585 111453
94	Crowborough Beacon Botley Hill - *Bestbeech Windmill*	108 18	47 39	35 16	Bestbeech Windmill	36056 106714
95	Crowborough Beacon Botley Hill - *Tatesfield Church*	5 90	2 24	39 37	Tatesfield Church	89897 7904

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
96	Crowborough Beacon Botley Hill - - *Godstone Windmill*	° ′ ″ 13 26 7 53 50 7	Godstone Wind-mill -	78333 22544

Botley Hill from Leith Hill 92632,2 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
97 D	Botley Hill - - Leith Hill - - *Charlwood Church*	17 5 35 36 33 33	Charlwood Church	68505 33804
98 D	Botley Hill - - Leith Hill - - *Evelyn's Obelisk*	54 41 39 33 25 22	Evelyn's Obelisk	51051 75636

Butser Hill from Hind Head 78905,7 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
99	Butser Hill - - Hind Head - *Petworth Windmill*	36 49 10 83 42 37	Petworth Wind-mill -	91054 54899

Portsdown Hill from Butser Hill 52729 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
100	Portsdown Hill - Butser Hill - - *Southwick Church*	41 34 33 4 31 23	Southwick Church	57710 48564

Dunnose from Butser Hill 140580,4 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
101	Dunnose - - Butser Hill - *Flagstaff of Carisbrook Castle*	67 7 31 14 59 6	Flagstaff, Caris-brook Castle -	36697 130763

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
102	Dunnose - - Butser Hill - *Halifax Tower*	° ′ ″ 15 4 28 49 11 35	Halifax Tower -	118122 40586

Portsdown Hill from Dunnose 90007 feet.

103	Portsdown Hill - Dunnose - - *Kingston Church, Portsea Island*	33 53 34 9 20 28	Kingston Church	21328 73274
104 D	Portsdown Hill - Dunnose - - *Horndean Church*	150 33 55 7 45 58	Horndean Church	33430 120320
105	Portsdown Hill - Dunnose - - *Titchfield Church*	72 28 16 18 46 40	Titchfield Church	28980 85848

Dunnose from Motteston Down 55104,3 feet.

106	Dunnose - - Motteston Down - *East Corner of the Roof of the great Boat House at the Back of the Isle of Wight*	12 13 22 35 10 30	Great Boat House	43127 15849

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
107	Dunnose - - Motteston Down - *Brixton Church, Isle of Wight*	° ′ ″ 5 3 4 25 53 6	Brixton Church	46795 9437
108	Dunnose - - Motteston Down - *East Cowes Sea Mark, Isle of Wight*	54 23 57 62 29 15	East Cowes Sea Mark - -	54796 50235
109	Dunnose - - Motteston Down - *Luttrell's Folly*	50 34 24 82 14 9	Luttrell's Folly	74424 58020
110	Dunnose - - Motteston Down - *Fawley Church*	48 58 19 90 32 45	Fawley Church	84875 64032
111	Dunnose - - Motteston Down - *Flagstaff, Calshot Cast.*	54 43 0 80 53 17	Flagstaff, Calshot Castle - -	77771 64296
112	Dunnose - - Motteston Down - *Fareham Church*	77 13 3 66 57 30	Fareham Church	86636 91814
113	Dunnose - - Motteston Down - *Porchester Church*	87 30 58 57 50 55	Porchester Church	82086 96863
114	Dunnose - - Motteston Down - *Hamble Church*	56 5 32 87 4 16	Hamble Church	91792 76281

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
115	Dunnose - - Motteston Down - *Hamble Saltern*	° ′ ″ 56 40 50 84 55 52	Hamble Saltern	88390 74150
116	Dunnose - - Motteston Down - *Gov. Hornsby's House, Centre Pediment.*	57 49 18 82 52 7	Gover. Hornsby's House - -	86309 73621
117	Dunnose - - Motteston Down - *Warblington Church*	106 36 6 48 57 49	Warblington Church -	100482 127660
118	Dunnose - - Motteston Down - *Burzledon Windmill*	58 39 40 89 30 11	Burzledon Wind-mill - -	104462 89225
119	Dunnose - - Motteston Down - *Porchester Castle*	87 8 20 58 16 27	Porchester Castle	82568 96952
120	Dunnose - - Motteston Down - *Havant Church*	104 5 1 50 25 55	Havant Church	98725 124221

Dean Hill from Four Mile-stone 56775 feet.

121	Dean Hill - - Four Mile-stone - *Winterslow Church*	42 54 34 21 6 1	Winterslow Church -	22739 43004

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
122	Dean Hill - - Dunnose - - *Farley Monument*	° ′ ″ 60 20 37 16 44 23	Farley Monument	53239 160629

Motteston Down from Nine Barrow Down 135489,6 feet.

123	Motteston Down - Nine Barrow Down *Hordle Church*	33 29 46 16 13 59	Hordle Church	49640 98000
124	Motteston Down - Nine Barrow Down *Mitford Church*	36 52 51 15 13 46	Mitford Church	45098 103035
125	Motteston Down - Nine Barrow Down *Hurst Light House*	33 17 31 9 49 13	Hurst Light House	33813 108820
* 125	Motteston Down - Nine Barrow Down *Hurst Castle*	33 32 2 9 48 47	Hurst Castle	33564 109043
126	Motteston Down - Nine Barrow Down *Cupola of Sir J. Doyley's House*	67 18 34 20 13 51	Sir J. Doyley's House	46896 125118
127	Motteston Down - Nine Barrow Down *Milton Church*	34 4 47 23 22 56	Milton Church	63782 90057
128	Motteston Down - Nine Barrow Down *North Chimney on Lord Bute's House*	27 1 16 24 13 18	Lord Bute's House	71283 78937

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	
		° ′ ″		Feet.
129	Motteston Down - Nine Barrow Down *Centre Pediment of Belvidere House*	28 48 39 25 29 50	Belvidere House	71813 80396

Dean Hill from Motteston Down 144766 feet.

130	Dean Hill - - Motteston Down - *Summer House on Kilminston Down*	66 5 5 44 20 32	Summer House Kilminston Down	107973 141217

Nine Barrow Down from Black Down 126782 feet.

131	Nine Barrow Down Black Down - - *Poole Church*	89 46 55 13 3 59	Poole Church	29399 130037
132	Nine Barrow Down Black Down - - *Funtingdon Church*	7 54 30 28 11 54	Funtingdon Church	101661 29601
133	Nine Barrow Down Black Down - - *Dorchester Church*	7 54 33 30 35 42	Dorchester Church	103647 28022
*133	Nine Barrow Down Black Down - - *Wyke Church, near Weymouth*	15 28 23 54 29 40	Wyke Church	109854 36002

Nine Barrow Down from Wingreen 130224,5 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
134	Nine Barrow Down Wingreen - - *Obelisk near Milbourn, St. Andrew's*	° ′ ″ 41 50 35 35 56 53	Obelisk near Milbourn - -	78218 88882
135	Nine Barrow Down Wingreen - - *Mr. Trenchard's Tower near Lytchet*	12 9 2 9 3 17	Mr. Trenchard's Tower - -	56660 75778
136	Nine Barrow Down Wingreen - - *Flagstaff, Mr. Pitt's Factory, Isle of Purbeck*	113 10 7 5 30 19	Flagstaff, Mr. Pitt's Factory	14240 136456
137	Nine Barrow Down Wingreen - - *Centre of the Barrow on Creech Hill, Isle of Purbeck*	73 32 14 10 38 14	Barrow on Creech Hill - -	24163 125534
138	Nine Barrow Down Wingreen - - *Vane on the Castle, Branksea Island*	40 45 31 7 37 13	Branksea Castle	23101 113731
139	Nine Barrow Down Wingreen - - *Horton Observatory*	18 12 9 27 4 38	Horton Observatory - -	83424 57250

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
		° ′ ″		
140	Nine Barrow Down Wingreen - - *Staircase of Alfred's Tower, in Stourhead Park*	14 51 23 138 58 56	Alfred's Tower -	193843 75729
141 D	Nine Barrow Down Wingreen - - *Ringwood Church*	42 27 24 45 8 30	Ringwood Church	92391 87983
142 D	Nine Barrow Down Wingreen - - *Summer House at Moyle's Court*	41 55 41 53 51 18	Summer House, Moyle's Court	105698 87461
143	Nine Barrow Down Wingreen - - *Christchurch Tower*	66 36 0 29 45 57	Christchurch -	65052 120256
144	Nine Barrow Down Wingreen - - *Warren Summer House, Christchurch Head*	72 43 29 29 13 29	Warren Summer House - -	64989 127104

Wingreen from Blackdown 149140 feet.

144*	Wingreen - - Blackdown - *Barrow, Swyre Head, Isle of Purbeck*	44 36 0 62 1 41	Swyre Head -	137466 109289

Motteston Down from Wingreen 197090 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the objects intersected.	Feet.
145 D	Motteston Down - Wingreen - - *Sopley Church*	° ′ ″ 11 6 40 10 13 47	Sopley Church -	96183 104370

Dean Hill from Beacon Hill 58086,3 feet.

146	Dean Hill - - Beacon Hill - *Salisbury Spire*	53 21 33 35 37 6	Salisbury Spire -	33834 46615

Beacon Hill from Four Mile-stone 38818,2 feet.

147	Beacon Hill - - Four Mile-stone - *Altar-piece at Stone Henge*	33 20 34 34 52 8	Altar-piece at Stone Henge	23900 22978
148	Beacon Hill - - Four Mile-stone - *Amesbury Church*	20 44 17 11 52 14	Amesbury Church	14817 25506
149	Beacon Hill - - Four Mile-stone - *South Chimney on Old Hartford Hut, Salisbury Plain*	16 26 51 56 13 33	Old Hartford Hut	33801 11513
150	Beacon Hill - - Four Mile-stone - *Everley Church*	132 24 37 23 7 41	Everley Church	36822 69215

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects	
		° ′ ″		Feet.
151	Beacon Hill - - Four Mile-stone - *Summer House on Martincel's Hill, near Marlborough*	119 35 33 39 11 38	Summer House on Martincel's Hill	67794 93285
152	Beacon Hill - - Four Mile-stone - *North Windmill, Salisbury Plain*	45 4 20 81 52 17	North Windmill	48082 34387
153	Beacon Hill - - Four Mile-stone - *South Windmill, Salisbury Plain*	41 55 52 74 6 39	South Windmill	41554 28871

Beacon Hill from Wingreen 114522,4 feet.

154	Beacon Hill - - Wingreen - - *Clay Hill Barrow, near Warminster*	42 46 45 70 18 36	Clay Hill Barrow, or Copt Heap -	117216 84554

Triangles for finding the Distance of Portsmouth Observatory from Dunnose.

Dunnose from Motteston Down 55104,3 feet.

No.	Triangles.	Angles observed.	Distances of the stations from the intersected objects.	Feet.
155	Dunnose - - Motteston Down - *Spindle of the Wind Vane on Portsmouth Church Tower*	° ′ ″ 92 44 48 48 44 27	Portsmouth Church	66524 88393
156	Dunnose - - Motteston Down - *Ball of the Cupola of Portsmouth Academy*	91 35 32 50 43 36	Portsmouth Academy -	69787 90113

In order to ascertain the situation of the Observatory, Mr. Bayly, Master of the Academy, measured two angles in the following triangle, viz.

	°	′	″
Portsmouth Academy	124	9	15
Observatory -	53	6	15
Portsmouth Church			

The included angle at Dunnose between the Ball on the Cupola of the Academy, and the Spindle of the Wind Vane on Portsmouth Church, is 1° 9′ 16″, and the distances of those objects from Dunnose are 66524 and 69787 feet; therefore the distance between the Academy and the Church will be 3540 feet:

this distance, used as a base in the above triangle, gives the distance between the Observatory and the Church 3663 feet; now the angle at the Church, comprehended by the Academy and the Observatory, being 2° 44′ 30″, we shall find the angle at Dunnose, between Portsmouth Church and the Observatory, to be 1° 3′ 30″, and the distance of the Observatory from Dunnose 69962 feet.

Remarks.

In an operation of this kind, it naturally follows, when the objects intersected are at considerable distances from the stations, there must be great difficulty in ascertaining their precise situations from the appearance of the country. Under such circumstances their names sometimes cannot be discovered; and it has been found, that the best maps of which we are in possession, were by no means sufficiently correct to be of much service in that particular. It is obvious also, without a very intimate knowledge of the interior parts of the country, (of which it is impossible, in the present state of the survey, we can be altogether possessed), there must be some difficulty to identify them, when their distances exceed twelve or fourteen miles. We have, therefore, when such an uncertainty existed, had recourse to some intelligent person well acquainted with the country, by whom we have been informed of their names. In this respect we have to acknowledge the services of Mr. Gardner, chief Draftsman at the Tower, by whose assistance, from his intimate knowledge of the county of Sussex, we have been able to determine, with certainty, the names of many places, which we might otherwise have considered as doubtful. Of the triangles here given, there is not much reason to believe

there has been any misnomer; but, as there is not altogether a certainty that all are rightly named, or the objects actually intersected, we have prefixed a D to those we consider as doubtful.

It may be proper to observe, that in taking the angles, the most defined parts of the objects have been selected; unless they were church towers without spires or pyramidical roofs, when the angles were taken to the middles of the towers. If the objects were windmills, resting (as they sometimes do) on great spindles, the observations have been made to those spindles; but in other cases, when the supports were undefined, the mills themselves were intersected.

SECTION EIGHTH.

Containing the Distances of the Objects intersected in the Course of the Survey, from the Meridian of Greenwich, Beachy Head, *or* Dunnose; *and from the Perpendiculars to those Meridians; with their Bearings, at the several Stations, from the Parallels to the Meridians. Also the Latitudes and Longitudes of those Objects.*

ART. I. *Bearings and Distances.*

Meridian of Greenwich.

Bearings from the Parallels to the Meridian.					Distances from merid.	Distances from perp.
At Brightling.	°	′	″		Feet.	Feet.
Bexhill Church -	29	19	25	SE	110956	230225
Westham Church -	11	41	43	SW	76392	240833
Pevensey Church -	9	56	0	SW	78214	240023
Black Heath Windmill	87	6	34	NW	73212	187407
Ninefield Church -	20	41	53	SE	97887	216129
Mountfield Church -	78	10	9	SE	112221	193338
At Ditchling Beacon.						
Chittingly Church -	88	37	2	NE	45462	208569
Waldron Church -	60	43	18	NE	41227	173423
Firle Beacon Station -	63	33	11	SE	25332	235029
Firle Church -	65	24	0	SE	20759	230963
Jevington Windmill -	62	8	28	SE	54978	252248
Plumpton Church -	81	34	20	NE	16211	209034

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Bearings from the Parallels to the Meridian.	°	′	″		Distances from merid.	Distances from perp.
At Ditchling Beacon.					Feet.	Feet.
Little Horsted Church	70	53	38	NE	21521	194326
Spittal Windmill -	65	58	55	SE	5690	218625
Ditchling Church -	14	30	17	NW	26325	203077
Thakeham Church -	77	33	40	NW	96831	194295
West Grinsted Church	63	20	56	NW	76612	184087
Keymere Church -	35	37	57	NW	29309	203504
Bolney Church - -	34	26	16	NW	46539	178068
Slaugham Church -	24	48	29	NW	47538	160346
Starting House, Brighton	2	28	47	SW	25605	236511
Cuckfield Church -	12	20	25	NW	32711	172580
Wyvelsfield Church -	6	29	54	NE	21592	185011
Hurstpierpoint Church	55	0	49	NW	41262	198504
Lindfield Church -	9	10	51	NE	17832	169199
At Crowboro. Beacon.						
Willington Church -	14	31	53	SE	56724	238159
Homehurst Church -	70	4	58	SE	90204	175142
Hailsham Church -	20	4	48	SE	60458	224245
Dallington Church -	51	17	56	SE	82994	193493
At Botley Hill.						
East Grinsted Church	1	14	6	SW	1039	129041
Rotherfield Church -	30	46	22	SE	50573	157520
Mayfield Church -	32	38	58	SE	60300	166723
Crowborough Chapel	25	6	50	SE	38257	154132
Bestbeech Windmill -	41	42	55	SE	71183	152539
Fairden Tower - -	4	11	47	SE	3448	117538
Tatesfield Church -	66	31	44	NE	7422	69733
Godstone Windmill -	30	46	28	SW	11363	92251
Charlwood Church -	49	25	48	SW	51866	117435
Evelyn's Obelisk - -	11	49	44	SW	10294	122847

Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Leith Hill.	° ′ ″	Feet.	Feet.
Firle Windmill -	40 18 35 SE	21292	234831
Beddingham Windmill	38 37 12 SE	14819	234476
Horsham Church -	11 54 25 SE	75805	152405
Farnham Castle -	80 43 18 NW	183432	93669
Euhurst Windmill -	86 21 38 SW	105295	111088
Euhurst Church -	62 16 42 SW	100845	118215
St. Martha's Chapel -	63 45 21 NW	120899	91983
Norris's Obelisk (Bagshot Heath) - -	54 14 15 NW	168622	49407
West Hoathly Church	63 6 5 SE	12367	146525
Nettlebed - -	43 12 55 NW	224159	38548
At Beachy Head.			
Hurstmonceux Church	21 26 48 NE.	76041	225562

Meridian of Beachy Head.

At Chanctonbury Ring.			
Sleep Down - -	32 8 34 SE	137183	42974
BrighthelmstoneChurch	64 14 21 SE	91925	31539
Shoreham Church -	46 37 4 SE	121788	34490
Southwick Church -	54 55 30 SE	114171	35161
Goring Church -	20 14 11 SW	158281	26132
Bramber Windmill -	75 17 59 SE	125507	52383
Findon Temple - -	56 38 48 SW	157711	50573

Meridian of Dunnose.

At Hind Head.			
Petworth Church -	28 4 40 SE	135688	135394
Kirdford Church -	50 50 28 SE	149419	150447
Wisborough Green Chu.	55 49 26 SE	160414	148101
Billinghurst Church -	61 20 7 SE	172148	148322
Rusper Church -	87 55 49 NE	211158	185404

Bearings from the Parallels to the Meridian.		Distances from merid.	Distances from perp.
At Butser Hill.	° ′ ″	Feet.	Feet.
Pulborough Church -	86 21 25 SE	159482	124313
E. of Egremont's Tower	83 43 30 NE	128906	139903
Bosham Church -	27 20 55 SE	78379	77027
Selsea Church - -	31 37 53 SE	100296	50141
Prinsted Windmill -	15 54 28 SE	64678	80914
Del Key Windmill -	33 41 48 SE	88659	73781
Horse-shoe Summer House - -	41 57 52 SW	26952	45327
Southampton Spire -	73 45 14 SW	47618	102722
Selsea Windmill -	24 42 33 SE	91103	42649
Flagstaff, Chichester Harbour - -	9 34 59 SE	62428	59596
Cackham Tower -	16 1 52 SE	71823	56455
Selsea High House -	24 40 58 SE	91791	41045
Bourn Church - -	15 55 58 SE	62546	88464
Ower Rocks - -	32 27 33 SE	122570	17687
South Hayling Church	0 51 26 SE	51324	64727
West Thorney Church	15 53 8 SE	67055	72486
Bow Hill Station -	48 55 14 SE	85116	100937
St. Cath. Light House	27 54 46 SW	24258	9529
Needles Light House	50 9 27 SW	86554	17045
Worsley's Obelisk -	25 7 34 SW	11607	796
Ashey Down Sea Mark	24 6 10 SW	2471	24292
Cowes Fort - -	43 49 1 SW	21998	55887
Portsdown Windmill	24 15 6 SW	30055	86262
Clark's Folly - -	10 4 51 SW	42250	85825
South Sea Castle -	18 51 36 SW	25425	58361
Portsdown Hill Station	34 2 0 SW	20816	87565
Petworth Windmill -	87 0 38 NE	141258	136012
At Rook's Hill.			
West Tarring -	73 52 32 SE	185568	76299
High Down Windmill	72 3 14 SE	172934	77511
Angmering Church -	69 38 4 SE	164937	77159
Pagham Church -	1 25 13 SE	104222	55757

Bearings from the Parallels to the Meridian.					Distances from merid.	Distances from perp.
At Rook's Hill.	°	′	″		Feet.	Feet.
Bersted Church -	27	7	47	SE	121063	64535
Clapham Church -	75	30	37	SE	169507	82990
Oving Church -	20	27	27	SE	110141	80477
Felpham Windmill -	30	41	22	SE	125546	61860
Boxgrove Church -	40	11	21	SE	112647	88543
Goodwood House -	23	44	31	SE	105966	92970
Portfield Windmill -	5	6	41	SW	101125	81847
Chichester Spire -	16	47	40	SW	96603	79801
Harting Windmill -	48	13	28	NW	75678	124438
Sir H. Fetherstonhaugh's Tower - -	51	25	10	NW	72732	124196
Sir R. Hotham's Flagstaff	22	57	0	SE	120029	59477
At Dunnose.						
Kingston Church -	22	42	52	NE	28294	67591
Horndean Church -	21	8	22	NE	43392	112223
Titchfield Church -	5	24	16	NW	8086	85466
Porchester Castle -	13	33	12	NE	19350	80269
Halifax Tower -	36	3	7	NE	69517	95499
Carisbrook Castle -	46	10	52	NW	26478	25408
Thorness Station -	43	0	59	NW	39207	42020
Luttrell's Folly -	23	0	44	NW	29094	68502
Great Boat House -	85	48	30	NW	43011	3152
Brixton Church -	78	38	12	NW	45878	9220
Calshot Castle -	18	52	8	NW	25151	73592
Fawley Church -	24	36	49	NW	35350	77163
East Cowes Sea Mark	19	11	11	NW	18008	51752
Bursledon Windmill -	14	55	28	NW	26904	100938
Hamble Church -	17	29	36	NW	27592	87546
Hamble Saltern	16	54	18	NW	25702	84570
Gov. Hornsby's House	15	45	50	NW	23448	83063
Warblington Church	33	0	58	NE	54750	84255
Farley Monument -	18	0	4	NW	49640	152765
Portsmouth Church -	19	9	40	NE	21835	62839

Bearings from the Parallels to the Meridian.	°	′	″		Distances from merid.	Distances from perp.
					Feet.	Feet.
At Dunnose.						
Portsmouth Academy	18	0	24	NE	21573	66369
———— - Observatory	18	6	10	NE	21739	66499
Fareham Church -	3	37	55	NE	5488	86462
Porchester Church -	13	55	50	NE	19762	79672
Havant Church - -	30	29	53	NE	50104	85066
At Dean Hill.						
Salisbury Spire -	68	52	9	NW	136127	162983
Stockbridge Hill Station	55	40	12	NE	59673	181446
Winterslow Church -	12	5	5	NW	c9329	173021
At Four Mile-stone.						
North Windmill, Salisbury Plain -	21	11	6	NW	161506	210275
South Windmill, Salisbury Plain - -	28	56	44	NW	167717	213446
At Motteston Down.						
Ramsden Hill Station	65	47	6	NW	141369	55377
Hordle Church -	60	14	32	NW	95952	40210
Mitford Church -	56	51	27	NW	90619	40228
Milton Church -	59	39	31	NW	107904	47792
Hurst Light House -	60	26	47	NW	82272	32250
Hurst Castle - -	60	12	16	NW	81985	32249
Lord Bute's House -	66	43	2	NW	118336	43747
Summer House, Kilminston Down -	23	24	52	NE	3259	145161
Sir J. Doyley's House -	26	25	44	NW	73731	57566
Belvidere House -	64	55	39	NW	117904	46004
Sopley Church -	63	44	46	NW	139119	58118
At Nine Barrow Down.						
Wyke Church - -	84	7	0	SW	297337	4524
Horton Observatory -	8	43	26	NE	175408	89196
Branksea Castle -	31	16	48	NE	176067	26479
Swyre Head - -	65	41	52	SW	208018	2275

Bearings from the Parallels to the Meridian.					Distances from merid.	Distances from perp.
At Nine Barrow Down.	°	′	″		Feet.	Feet.
Ringwood Church -	32	58	41	NE	137771	84242
Moyle's Court Summer House - -	32	26	58	NE	131348	95932
Christchurch Tower	57	7	17	NE	133429	42051
Christchurch Head -	63	14	46	NE	130030	35992
Poole Church -	9	22	18	NE	183274	35743
Pitt's Factory -	57	21	10	SW	200051	945
Creech Barrow -	83	0	57	NW	212045	9675
Mr. Trenchard's Tower	21	37	45	NW	208946	59407
Obelisk, near Milbourn	51	19	18	NW	249123	55619
Funtingdon Church -	72	30	7	NW	285016	37303
Dorchester Church -	72	30	4	NW	286911	37901
Alfred's Tower -	24	20	6	NW	267938	183357
At Beacon Hill.						
Amesbury Church -	73	39	50	SW	134320	202589
Summer House, Martincel's Hill - -	7	28	54	NW	128928	273974
Everley Church -	5	20	10	NE	116677	243419
Stone Henge - -	86	16	7	SW	143950	205202
Old Hartford Hut -	69	22	24	SW	151735	194850
Clay Hill, or Copt Heap	85	54	8	NW	237017	215133

The bearings of the objects from the parallels to the meridians at the different stations, are inserted in the above table, in order that the numbers in the two last columns may be examined with greater facility. They have been obtained thus:

At Beacon Hill, the bearing of Clay Hill is 85° 54′ 8″ NW; this, with the distance between Beacon Hill and Clay Hill, give 116916, and 8376 feet, for the distances of the latter

place from the parallels to the meridian of Dunnose, and its perpendicular. But the distances of Beacon Hill from that meridian, and perpendicular, are 120101 feet, and 206757 feet; therefore $120101 + 116916 = 237017$ feet, and $206757 + 8376 = 215133$ feet, are the distances of Clay Hill from the meridian of Dunnose, and its perpendicular.

ART. II. *Containing the Latitudes and Longitudes of such Places upon the Sea Coast, and near it, as have been referred to the Meridian of* Greenwich.

Names of objects.	Latitude.	Longitude from Greenwich. In degrees		In time.
	° ′ ″	° ′ ″		m. s.
Bexhill Church -	50 50 46,7	0 28 43,3	E	1 54,9
Pevensey Church -	50 49 11,9	0 20 14,1	E	1 20,9
Westham Church -	50 49 4	0 19 45,8	E	1 19
Willingdon Church	50 49 31,2	0 14 40,6	E	0 58,7
Jevington Windmill	50 47 12,3	0 14 12,8	E	0 56,9
Firle Beacon Station	50 50 2,7	0 6 33,3	E	0 26,2
Firle Windmill -	50 50 4,8	0 5 30,6	E	0 22
Firle Church - -	50 50 42,9	0 5 22,4	E	0 21,5
Beddingham Windmill	50 50 8,3	0 3 50,1	E	0 15,3
Hailsham Church -	50 51 48,2	0 15 39,3	E	1 2,6
Spittal Windmill -	50 52 44,7	0 1 28,3	W	0 26
Starting House, Brighton - -	50 49 48,1	0 6 28,5	W	0 25,9

ART. III. Containing the Latitudes and Longitudes of such Places upon the Sea Coast, and near it, as have been referred to the Meridian of Beachy Head.

Names of objects.	Latitude.	Longitude west of Beachy Head.	Longitude west of Greenwich. In degrees.	Longitude west of Greenwich. In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Brighthelmstone Church -	50 49 32,2	0 27 7,1	0 11 55,2	0 47,7
Southwick Church - -	50 50 6,6	0 29 32,8	0 14 20,9	0 57,3
Shoreham Church -	50 49 59,5	0 31 31	0 16 19,1	1 5,3
Bramber Windmill - -	50 52 55,7	0 32 30,8	0 17 18,9	1 9,3
Sleep Down Station -	50 51 22,1	0 35 31,1	0 20 19,2	1 21,3
Goring Church - -	50 48 34,2	0 40 56,5	0 25 44,6	1 43
Findon Temple - - -	50 52 15	0 40 50,8	0 25 38,9	1 42,6

ART. IV. Containing the Latitudes and Longitudes of such Places upon the Sea Coast, and near it, as have been referred to the Meridian of Dunnose.

Names of objects.	Latitude.	Longitude from Dunnose.		Longitude west of Greenwich. In degrees.	Longitude west of Greenwich. In time.
	° ′ ″	° ′ ″		° ′ ″	m. s.
West Tarring Church - -	50 49 29,8	0 48 1	E	0 23 35	1 34,3
High Down Windmill -	50 49 42,9	0 44 45	E	0 26 51	1 47,4
Clapham Church - -	50 50 37,3	0 43 52,6	E	0 27 43,4	1 50,9
Angmering Church - -	50 49 40,3	0 42 40,8	E	0 28 55,2	1 55,7
Felpham Windmill -	50 47 12,7	0 32 27,6	E	0 39 8,4	2 36,6
Bersted Church - -	50 47 39,4	0 31 18,2	E	0 40 17,8	2 41,2
Gov. Hornsby's House -	50 50 46,1	0 6 4,2	W	1 17 40,2	5 10,7
Sir R. Hotham's Flagstaff -	50 46 49,6	0 31 1,7	E	0 40 34,3	2 42,3
Oving Church - -	50 50 17,3	0 28 30,4	E	0 43 5,6	2 52,4
Pagham Church - -	50 46 14	0 26 56,1	E	0 44 39,9	2 58,7
Chichester Spire - - -	50 50 11,4	0 25 0,1	E	0 46 35,9	3 6,4
Selsea Church - -	50 45 18,8	0 25 54,7	E	0 45 41,3	3 2,7
Selsea High House -	50 43 49,6	0 23 42,2	E	0 47 53,8	3 11,5
Selsea Windmill - -	50 44 5,4	0 23 31,6	E	0 48 4,4	3 12,3
Del Key, or Dalkey Windmill -	50 49 12,5	0 22 56,3	E	0 48 39,7	3 14,6
Bosham Church - - -	50 49 45	0 20 16,9	E	0 51 19,1	3 25,3
Cackham Tower - -	50 46 22,4	0 18 33,7	E	0 53 2,3	3 32,2
West Thorney Church -	50 49 0,7	0 17 20,8	E	0 54 15,2	3 37
Prinsted Windmill - -	50 50 23,9	0 16 44,4	E	0 54 51,6	3 39,4
Watch House, Chichester Harbour	50 46 53,8	0 16 8,3	E	0 55 27,7	3 41,8
West Bourn Church - -	50 51 38,4	0 16 11,7	E	0 55 24,3	3 41,6
Warblington Church -	50 50 57,1	0 14 10,4	E	0 57 25,6	3 49,7
South Hayling Church -	50 47 44,7	0 13 16,1	E	0 58 19,9	3 53,3
Clark's Folly - -	50 51 13	0 10 56,3	E	1 0 39,7	4 2,6

Names of objects.	Latitude.	Longitude from Dunnose.	Longitude west of Greenwich. In degrees.	In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Cumberland Fort	50 47 20,8	0 9 53,2 E	1 1 43	4 6,9
Kingston Church	50 48 13,5	0 7 19,1 E	1 4 16,9	4 17,1
Havant Church	50 51 5,4	0 12 58,3 E	0 58 37,7	3 54,5
Portsdown Windmill	50 51 17,6	0 7 46,9 E	1 3 49,1	4 15,3
Portsdown Station	50 51 30,6	0 5 23,4 E	1 6 12,6	4 24,8
Portsmouth Church	50 47 26,8	0 5 38,7 E	1 5 57,3	4 23,8
Portsmouth Academy	50 48 1,6	0 5 34,7 E	1 6 1,3	4 24,1
Portsmouth Observatory	50 48 2,9	0 5 37,3 E	1 5 58,7	4 23,9
South Sea Castle	50 46 42,5	0 6 34,3 E	1 5 1,7	4 20,1
Porchester Church	50 50 12,7	0 5 6,9 E	1 6 29,1	4 25,9
Porchester Castle	50 50 18,6	0 5 0,5 E	1 6 35,5	4 26,3
Fareham Church	50 51 19,8	0 1 25,3 E	1 10 10,7	4 40,7
Titchfield Church	50 51 10	0 2 5,6 W	1 13 41,6	4 54,8
Hamble Saltern	50 51 0,9	0 6 39,2 W	1 18 15,2	5 13
Hamble Church	50 51 30,3	0 7 8,6 W	1 18 44,6	5 15
Calshot Castle	50 43 12,7	0 6 29,6 W	1 18 5,6	5 12,4
Luttrell's Folly	50 48 22,5	0 7 31,5 W	1 19 7,5	5 16,5
Fawley Church	50 49 47,7	0 9 8,4 W	1 20 44,4	5 22,9
Hurst Castle	50 42 23,4	0 21 9,5 W	1 32 45,5	6 11
Hurst Light House	50 42 23,4	0 21 14 W	1 32 50	6 11,3
Ashey Down Sea Mark	50 41 6,8	0 0 38,2 E	1 10 57,8	4 43,8
East Cowes Sea Mark	50 45 37,5	0 4 39,2 W	1 16 15,2	5 5
West Cowes Fort	50 46 18,2	0 5 41,1 W	1 17 17,1	5 9,1
St. Catherine's Light House	50 35 33,1	0 6 14,7 W	1 17 50,7	5 11,3
Needles Light House	50 39 53,2	0 22 19,2 W	1 33 55,2	6 15,7
Mitford Church	50 43 41,7	0 23 23,9 W	1 34 59,9	6 20
Milton Church	50 44 55,2	0 27 52,4 W	1 39 28,4	6 37,9
Hordle Church	50 43 41,2	0 24 46,5 W	1 36 22,5	6 25,5
Lord Bute's House	50 44 14,5	0 30 33,7 W	1 42 9,7	6 48,6
Christchurch Head	50 42 57,3	0 33 34,5 W	1 45 10,5	7 0,7
Christchurch Tower	50 43 56,8	0 34 27,4 W	1 46 3,4	7 4,2
Ramsden Hill	50 46 7,5	0 36 32 W	1 48 8	7 12,5
Castle, Branksea Island	50 41 19,5	0 45 25,5 W	1 57 1,5	7 48,1
Poole Church	50 42 50	0 47 18,6 W	1 58 54,6	7 55,6
Flag-staff, Mr. Pitt's Factory	50 36 46,5	0 51 31,9 W	2 3 7,9	8 12,5
Creech Barrow	50 38 9,8	0 54 38,9 W	2 6 14,9	8 25
Barrow, Swyre Head	50 36 32,4	0 53 34,8 W	2 5 10,8	8 20,7
Boat House	50 37 37,9	0 11 4,9 W	1 22 40,9	5 30,7
Wyke Church	50 35 57,5	1 16 34,2 W	2 28 10,2	9 52,7
Brixton Church	50 38 37,6	0 11 49,2 W	1 23 25,2	5 33,7
Horse-shoe Summer House	50 44 34,2	0 6 57,7 W	1 18 33,7	5 14,2
Sir R. Worsley's Obelisk	50 36 59,5	0 2 59,4 W	1 14 35,4	4 58,3
Ower Rocks	50 39 57,3	0 31 36,5 E	0 39 59,5	2 40

ART. V. Containing the Latitudes and Longitudes of those Places, remote from the Sea Coast, which have been referred to the Meridian of Greenwich.

Names of objects.	Latitude.	Longitude from Greenwich. In degrees.		Longitude from Greenwich. In time.
	° ′ ″	° ′ ″		m. s.
East Grinsted Church	51 7 27,9	0 0 16,2	E	0 1,1
Fairden Tower	51 9 21,3	0 0 53,9	E	0 3,6
Tatesfield Church	51 17 12,6	0 1 56,4	E	0 7,7
Evelyn's Obelisk, Felbridge Park	51 8 28,9	0 2 40,9	W	8 10,7
Godstone, or Tilburster Windmill	51 13 30,5	0 2 57,9	W	0 11,9
West Hoathly Church	51 4 35,4	0 3 13	W	0 12,9
Plumpton Church	50 54 19,1	0 4 12,1	W	0 16,8
Lindfield Church	51 0 52	0 4 38	W	0 18,5
D Wyvelsfield Church	50 58 16	0 5 36,3	W	0 22,4
Little Horsted Church	50 56 44,1	0 5 35	E	0 22,3
Ditchling Church	50 55 17,8	0 6 49,5	W	0 27,3
Keymer Church	50 55 13,6	0 7 35,9	W	0 30,4
Cuckfield Church	51 0 18,3	0 8 29,8	W	0 34
Waldron Church	51 0 9,8	0 10 42,5	E	0 42,8
Crowborough Chapel	51 3 20,1	0 9 56,8	E	0 39,7
Hurstpierpoint Church	50 56 2,5	0 10 42,1	W	0 42,8
Chittingly Church	50 54 23,2	0 11 47	E	0 47,1
Bolney Church	50 59 23,9	0 12 5	W	0 48,3
Slaugham Church	51 2 18,7	0 12 21,4	W	0 49,4
Rotherfield Church	51 2 46,3	0 13 8,8	E	0 52,6
Charlwood Church	51 9 21,5	0 13 30,1	W	0 54
Mayfield Church	51 1 15,3	0 15 40	E	1 2,7
Homehurst Church	50 59 51	0 23 25,5	E	1 33,7
Bestbeech Windmill	51 3 34,8	0 18 30,7	E	1 14
Blackheath Windmill (near Heathfield)	50 57 50,9	0 19 0	E	1 16
Horsham Church	51 3 36	0 19 42,7	W	1 18,9
Hurstmonceux Church	50 51 34,6	0 19 41,7	E	1 18,8
West Grinsted Church	50 58 23,5	0 19 53,2	W	1 19,5
Dallington Church	50 56 50,4	0 21 31,8	E	1 26,1
Ninefield Church	50 53 7,1	0 25 21,6	E	1 41,4
Thakeham Church	50 56 41,8	0 25 7,1	W	1 40,5
Euhurst Church	51 9 11,7	0 26 16,6	W	1 45,1
Euhurst Windmill	51 10 21,7	0 27 26,9	W	1 49,9
Mountfield Church	50 56 50,4	0 29 6,7	E	1 56,4
St. Martha's Chapel	51 13 29	0 31 33,1	W	2 6,2
Norris's Obelisk	51 20 24,8	0 44 7	W	2 56,5
Farnham Castle	51 13 6,9	0 47 52	W	3 11,5
Nettlebed Station	51 34 45,1	0 58 57,1	W	3 55,8

ART. VI. Containing the Latitudes and Longitudes of those Places, remote from the Sea Coast, which have been referred to the Meridian of Dunnose.

Names of objects.	Latitude.	Longitude from Dunnose.	Longitude west of Greenwich. In degrees.	Longitude west of Greenwich. In time.
	° ′ ″	° ′ ″	° ′ ″	m. s.
Rusper Church - -	51 7 22,4	0 54 59,1 E	0 16 36,9	1 6,5
Billinghurst Church -	51 1 20,6	0 44 43,9 E	0 26 52,1	1 47,5
Pulborough Church - -	50 57 25,5	0 41 22,4 E	0 30 13,6	2 0,9
Kirdford Church - -	51 1 44,1	0 38 49,9 E	0 32 46,1	2 11,1
Petworth Windmill - -	50 59 22,5	0 36 40,7 E	0 34 53,3	2 19,6
Petworth Church - -	50 59 17	0 35 10,2 E	0 36 25,8	2 25,7
Earl of Egremont's Tower -	51 0 1,9	0 33 28,7 E	0 38 7,3	2 32,5
Wisborough Green Church -	51 1 20,1	0 41 41 E	0 29 55	1 59,7
Boxgrove Church - -	50 51 36,7	0 29 10,1 E	0 42 25,9	2 49,7
Portfield Windmill -	50 50 31,4	0 26 10,5 E	0 45 25,5	3 1,7
Rook's Hill Windmill -	50 53 17,2	0 25 48,9 E	0 45 47,1	3 3,1
Halifax Tower - -	50 52 47,5	0 18 0,4 E	0 53 35,6	3 34,4
Goodwood House - -	50 52 20,8	0 27 26,7 E	0 44 9,3	2 56,6
Bow Hill Station - -	50 53 40,4	0 22 3,3 E	0 49 32,7	3 18,2
Harting Windmill - -	50 57 32,7	0 19 38,2 E	0 51 57,8	3 27,8
Sir H. Fetherstonhaugh's Tower	50 57 30,3	0 18 52,3 E	0 52 43,7	3 30,9
Horndean Church - -	50 55 33,3	0 11 15,1 E	1 0 20,9	4 1,4
Southwick Church - -	50 52 27	0 5 11,7 E	1 6 24,3	4 25,6
Summer House, Kilminston Down	51 0 58,5	0 0 50,8 E	1 10 45,2	4 43
Carisbrook Castle - -	50 41 17,5	0 6 49,9 W	1 18 25,9	5 13,7
Bursledon Windmill - -	50 53 42,3	0 6 58,3 W	1 18 34,3	5 14,3
Thorness Station - -	50 44 1,1	0 10 7,5 W	1 21 43,5	5 26,9
Farley Monument - -	51 2 12,8	0 12 54,1 W	1 24 30,1	5 38
Southampton Spire -	50 53 59,5	0 12 20,4 W	1 23 56,4	5 35,8
Stockbridge Hill Station -	51 6 55,3	0 15 32,2 W	1 27 8,2	5 48,5
Sir J. Doyley's House -	50 46 33,3	0 19 3,4 W	1 30 39,4	6 2,6
Winterslow Church - -	51 5 29,7	0 28 27 W	1 40 3	6 40,2
Belvidere House - -	50 44 36,9	0 30 27,3 W	1 42 3,3	6 48,2
Everley Church - -	51 17 3,3	0 30 29,3 W	1 42 5,3	6 48,3
Ringwood Church - -	50 50 58	0 35 40 W	1 47 16	7 9,1
Summer House, Martincel's Hill	51 22 3,6	0 33 45 W	1 45 21	7 1,4
Summer House, Moyle's Court -	50 52 48,2	0 34 1,5 W	1 45 37,5	7 2,5
Amesbury Church - -	51 10 18,9	0 35 0,8 W	1 46 36,8	7 6,5
Salisbury Spire - -	51 3 48,9	0 35 24,2 W	1 47 0,2	7 8
Sopley Church - - -	50 46 34,7	0 35 57,5 W	1 47 33,5	7 10,2
Stonehenge - - -	51 10 44,3	0 37 31,8 W	1 49 7,8	7 16,5
Old Hartford Hut - -	51 9 1,8	0 39 32,1 W	1 51 8,1	7 24,5
S. Windmill } on Salisbury Plain	51 11 33	0 42 7,2 W	1 53 43,2	7 34,9
N. Windmill } on Salisbury Plain	51 12 3,4	0 43 44,8 W	1 55 20,8	7 41,4
Horton Observatory - -	50 51 37,9	0 45 25,3 W	1 57 1,3	7 48,1
Mr. Trenchard's Tower -	50 46 40,5	0 54 0,5 W	2 5 36,5	8 22,4
Clay Hill, or Copt Heap -	51 12 12	1 1 49,8 W	2 13 25,8	8 53,7
Alfred's Tower - -	51 6 54,4	1 9 45,5 W	2 21 21,5	9 25,4
Milbourn Obelisk - -	50 45 57,8	1 4 22,8 W	2 15 58,8	9 3,9
Funtingdon Church - -	50 42 52,2	1 13 35,5 W	2 25 11,5	9 40,7
Dorchester Church - -	50 42 57,7	1 14 4,1 W	2 25 40,1	9 42,7

SECTION NINTH.

Heights of the Stations. Terrestrial Refractions.

ART. I. *Height of the Station at* Dunnose.

With a view to obtain the heights of the stations nearly, from their elevations or depressions, we determined the height of that at Dunnose above low water in May, 1793, by levelling down to the sea shore near Shanklin, a distance of about a mile. Instead of a levelling telescope, we made use of the transit instrument, which, on account of its very accurate spirit level, seems extremely well adapted for the purpose. Two circular wooden platforms were provided, broad enough for the feet of the transit stand; these platforms rested on pegs driven into the ground, and were always made horizontal at the time of levelling, by means of a mahogany spar, or straight-edge, furnished with a spirit level. The graduated rods, of course, were constantly set vertical on the lowest platform, while the transit stood on the other.

The ground is favourable enough down to Shanklin Chine: this is a large deep chasm, opening to the sea; but the descent is not so sudden on the western side, which is by far the steepest, and to which we levelled, but a person may get up or down with safety. We found its perpendicular height by means of several rods placed end ways against the sloping side, and supported in an horizontal position, and then letting fall a measuring tape from one rod to another: but this was the most troublesome and difficult part of the whole operation. The fall from the bottom of this chasm or opening, to the water's edge, was found in the usual manner.

The whole perpendicular descent thus determined, was 792 feet; which, we have no reason to suppose, is more than 2 or 3

feet wide of the truth. We finished at low water on May 10; and therefore the height of the station above low water at spring tides will, no doubt, be some very few feet more.

ART. II. *Heights of* Rook's Hill *and* Butser Hill. *With Tables containing the Heights of the Stations, and the mean terrestrial Refractions.*

		′	″
At Dunnose	the ground at Rook's Hill was depressed	12	14
	at Butser Hill depressed -	6	10
At Rook's Hill	the ground at Dunnose was depressed -	7	37
	at Butser Hill elevated -	7	17
At Butser Hill	the ground at Dunnose was depressed -	12	36
	the top of a flagstaff at Rook's Hill depr.	15	12

	°	′	
Dunnose and Rook's Hill	23	31	contained arcs nearly.
Dunnose and Butser Hill	23	3	
Butser Hill and Rook's Hill	9	59	

The flagstaff at Rook's Hill was 20 feet high. And the axis of the telescope about $5\frac{1}{2}$ feet above the ground at each station.

From these observations, the mean refraction between Dunnose and Rook's Hill will be found 1′ 58″; between Dunnose and Butser Hill 2′ 16″; and between Butser Hill and Rook's Hill 39″; which are about $\frac{1}{12}$, $\frac{1}{10}$, $\frac{1}{15}$ of the contained arcs respectively, as in the table.

By the observations across the water, the ground at Rook's Hill would be 97 feet lower, and that at Butser Hill 131 feet higher than Dunnose; the sum is 228 feet for the difference of heights of Butser Hill, and Rook's Hill, obtained in this manner; but from the reciprocal observations, the ground at Rook's Hill is only 208 feet lower than at Butser Hill, which is less than the former difference by 20 feet; therefore, supposing each of the mean refractions to have produced an equal

error in the heights, we have $792 - 97 + \frac{20}{3} = 702$ feet, for the height of Rook's Hill; and $792 + 131 - \frac{20}{7} = 916$ for that of Butser Hill. From those two determinations, the others in table 1. have been obtained (the stations to the westward of Dunnose excepted) by taking the mean of the heights as derived from different routes. Those distinguished by an asterisk, were found by taking $\frac{1}{12}$ of the contained arc for refraction.

The refractions at the end of table 2, obtained from the dip of the horizon, are very consistent; each being nearly $\frac{1}{10}$ of the contained arc. The following were the observations:

At Leith Hill, on July 2, 1792, at 10 in the forenoon, the horizon of the sea through Shoreham Gap was depressed 30′ 6″. At Rook's Hill about noon on Sept. 2, 1792, the depression of the sea, in the direction of Chichester spire, was 25′ 30″. At Nine Barrow Down, about noon on April 11, 1794, in a south direction nearly, the depression was 24′ 16″.

The axis of the telescope was about $5\frac{1}{2}$ feet from the ground at each of those stations.

Table 1.

Stations.	Ground above low water.
	Feet.
Dunnose - - -	792
Rook's Hill - -	702
Butser Hill - -	916
Hind Head - -	923
Chanctonbury Ring -	814

Stations.	Ground above low water.
	Feet.
Leith Hill - -	993
Ditchling Beacon -	858
Beachy Head - -	564
Fairlight Down -	599
Brightling Down -	646
Crowborough Beacon -	804
Botley Hill - -	890*
Banstead - - -	576
Shooter's Hill - -	446
Hanger Hill - -	230
King's Arbour - -	118
Hampton Poor House -	86
St. Ann's Hill - -	240
Bagshot Heath -	463
Dean Hill - -	539
Beacon Hill - -	690
Old Sarum - -	266
Nine Barrow Down -	642
Highclere - -	900
Wingreen - -	941
Motteston Down -	698*
Bow Hill - -	702*
Portsdown Hill -	447*

Table 2.

Between	Mean Refraction.
Banstead and Shooter's Hill -	$\frac{1}{7}$ of the contained arc.
St. Ann's Hill and Hampton Poor House	$\frac{1}{8}$
Brightling and Beachy Head -	$\frac{1}{8}$
Beachy Head and Fairlight Down -	$\frac{1}{10}$
Dunnose and Butser Hill - -	$\frac{1}{10}$
Highclere and Butser Hill -	$\frac{1}{10}$
Butser Hill and Hind Head -	$\frac{1}{10}$
Beachy Head and Chanctonbury Ring	$\frac{1}{11}$
Highclere and Hind Head -	$\frac{1}{11}$
Rook's Hill and Dunnose - -	$\frac{1}{12}$
Leith Hill and Hind Head -	$\frac{1}{12}$
Bagshot Heath and St. Ann's Hill -	$\frac{1}{12}$
Dean Hill and Beacon Hill - -	$\frac{1}{12}$
St. Ann's Hill and Banstead -	$\frac{1}{12}$
Dunnose and Nine Barrow Down -	$\frac{1}{12}$
Leith Hill and Crowborough Beacon	$\frac{1}{13}$
Rook's Hill and Hind Head -	$\frac{1}{13}$
Dunnose and Dean Hill - -	$\frac{1}{13}$
Brightling and Fairlight Down -	$\frac{1}{13}$
Leith Hill and Chanctonbury Ring	$\frac{1}{13}$
Leith Hill and Shooter's Hill -	$\frac{1}{13}$
Brightling and Crowborough Beacon	$\frac{1}{14}$
Hanger Hill and Banstead -	$\frac{1}{14}$
Hanger Hill and St. Ann's Hill -	$\frac{1}{14}$
Leith Hill and Banstead - -	$\frac{1}{14}$
Beacon Hill and Wingreen -	$\frac{1}{15}$
Rook's Hill and Chanctonbury Ring	$\frac{1}{15}$

Between	Mean Refraction.
Dean Hill and Wingreen - -	$\frac{1}{15}$ of the contained arc.
Rook's Hill and Butser Hill -	$\frac{1}{15}$
Nine Barrow Down and Wingreen -	$\frac{1}{17}$
Leith Hill and Ditchling Beacon -	$\frac{1}{18}$
Mean of all the above, nearly -	$\frac{1}{12}$
Leith Hill and the Horizon -	$\frac{1}{10}$
Rook's Hill and the Horizon -	$\frac{1}{10}$
Nine Barrow Down and the Horizon	$\frac{1}{10}$

ART. III. *Remarks on the foregoing Tables.*

The height of the ground at the station on St. Ann's Hill, table 1, is 240 feet; but according to General ROY (Phil. Trans. Vol. LXXX. p. 232) it is 321 feet: this very great disagreement, however, principally arises from the variableness in the terrestrial refraction. In 1787, at the station near Hampton Poor House, the ground at St. Ann's Hill was elevated 17′ 39″; but at the same station in 1792, *when the axis of the instrument was at the same height above the ground*, the elevation was only 8′ 11″. General ROY took $\frac{1}{10}$ of the contained arc for the effect of refraction, and considered the height of St. Ann's Hill, when deduced from that of the station near Hampton Poor House, as more accurate than could be obtained by way of the station at the Hundred Acres. But, previous to the survey in 1787, he found by the barometer, that the station on St. Ann's Hill was 200 feet higher than the Thames at Shepperton; and he added 33 feet for the descent to low water at the sea; the sum is 233 feet, agreeing nearly with our determination.

We take the height of Botley Hill (890 feet) a mean of 900,885,885, which the observations at Leith Hill, Banstead, and Crowborough Beacon respectively produce, by making use of $\frac{1}{12}$ of the contained arcs for refraction : this height exceeds that in General Roy's table by 31 feet; but we are not certain of its being nearer the truth : only it may be remarked, in the table, p. 246 (Phil. Trans. Vol. LXXX.), that between the several stations from High Nook to Botley Hill, the mean refractions are very great.

From the reciprocal observations at Leith Hill, Banstead, and Shooter's Hill, the height of the last station is 446 feet, which is the same, in fact, as that obtained in the following manner. General Roy found by levelling, that the floor of the upper story of the Bull Inn at Shooter's Hill was 444 feet above the Gun Wharf at Woolwich; and he allowed 22 feet for the fall to low water at the sea; the sum is 466 feet. In 1794, we levelled from the Inn to the Station, and found the latter 21 feet lower than the floor, which taken from 466, there remains 445 feet for the station's height.

Notwithstanding this consistency, and also that in the height of St. Ann's Hill, found by different methods, it is evident from the observations at Dunnose, Rook's Hill, and Butser Hill, that relative heights deduced from elevations, or depressions, cannot always be depended upon to less than about 10 feet, even supposing those heights are the means of two or three independent results, except, perhaps, reciprocal observations were made exactly at the same time. The very great difference in the observed elevations of St. Ann's Hill, proves that no dependance can be placed on single observations. But that was not the only instance; for, at the station on Rook's

Hill, we found the depression of the ground at Chanctonbury Ring, vary from 1′ 41″ to 2′ 30″. The observations, however, on which the tables are founded, were made in close cloudy days, or toward the evenings, when the tremulous motion in the air is commonly the least.

It has been conjectured, that the variations in terrestrial refraction, depend on the changes in the atmosphere indicated by the barometer and thermometer: this, however, cannot be the case when the rays of light pass near the earth's surface for any considerable distance. M. DE LA LANDE, in his Astronomy (Art. *Terrest. Ref.*), remarks, that the mountains in Corsica are sometimes seen from the coasts of Genoa and Provence, but at other hours on the same days, they totally disappear, or are lost as it were in the sea. And the late General ROY frequently mentioned an instance of extraordinary refraction, which himself and Colonel CALDERWOOD observed on Hounslow Heath, when they were tracing out the base. Their levelling telescope at King's Arbour was directed towards Hampton Poor House, where a flagstaff was erected at that end of the base; this for a long time they endeavoured in vain to discover, till at last, very unexpectedly, it suddenly started up into view, and so high it seemed to be lifted, that the surface of the ground where it stood, became visible. This will appear the more extraordinary, when it is considered, that a right line drawn from the eye at King's Arbour to the other end of the base, would pass 8 or 9 feet below the surface of the intermediate ground near the Duke of ST. ALBANS Park. The following is still more singular. "I observed," says Mr. DALBY, "what seemed to me a very uncommon effect of ter-"restrial refraction, in April, 1793, as I went from Freshwater

"Gate, in the Isle of Wight, towards the Needles. Soon after "you leave Freshwater Gate, you get on a straight and easy "ascent, which extends 2 or 3 miles; a mile, or perhaps a mile "and an half beyond this to the westward, is a rising ground, "or hill; and it is to be remarked, that its top and the afore-"said straight ascent, are nearly in the same plane: now in "walking towards this hill, I observed that its top (the only "part visible) seemed to dance up and down in a very extra-"ordinary manner; which unusual appearance however, evi-"dently arose from unequal refraction, and the up-and-down "motion in walking; but when the eye was brought to about "2 feet from the ground, the top of the hill appeared totally "detached, or lifted up from the lower part, for the sky was "seen under it. This phænomenon I repeatedly observed. "There was much dew, and the sun rather warm for the sea-"son, consequently a great evaporation took place at that "time." Here, and also on Hounslow Heath, the rays of light passed near the earth's surface a great way before they arrived at the eye; and it is more than probable, that moist vapours were the principal cause of the very unusual refractions: the truth of which conjecture seems to be verified by the following circumstance. In measuring the base on Hounslow Heath, we had driven into the ground, at the distance of 100 feet from each other, about 30 pickets, so that their heads appeared through the boning telescope to be in a right line; this was done in the afternoon. The following morning proved uncommonly dewy, and the sun shone bright; when having occasion to replace the telescope, we remarked that the heads of the pickets exhibited a curve, concave upwards, the farthermost pickets rising the highest; and we concluded they were

not properly driven, till in the afternoon, when we found that the curve appearance was lost, and the ebullition in the air had subsided.

The new raised earth about the gun at King's Arbour, prevented a very accurate measurement of the height of the instrument above the point of commencement of the base; and therefore two opportunities only presented themselves for determining the actual terrestrial refraction; namely, at the ends of the base of verification. From the depression taken at Beacon Hill, the refraction was 38″; but the elevation of Beacon Hill, observed at the lower end, near Old Sarum, gives 50″. These deductions, perhaps, cannot be deemed very conclusive; because, as they depend on the difference in the vertical heights of the ends of the base, every 2 inches of error in that difference will produce an error of about 1″ in the computed refraction. We shall close this section with the *data* whence those refractions were obtained.

At Beacon Hill, the top of the flagstaff near Old Sarum was depressed 42′ 6″.

At the other end of the base, near Old Sarum, the top of the flagstaff at Beacon Hill was elevated 38′ 42″.

The axis of the telescope at Beacon Hill was 15 inches above, and the top of the flagstaff 91 inches above the point where the mensuration began. Near Old Sarum it was 28 inches higher, and the top of that flagstaff 95 inches above where the base terminated. This end (see Sect. III.) is 429,48 feet lower than the other. Lastly, the value of the base is 6′ of a degree, very nearly.

CONCLUSION.

Having communicated to the public, through the very respectable medium of the Royal Society, the particulars relating to the trigonometrical operation, we shall close the work with a few remarks concerning it.

In this early stage of the survey, the first object in view, has been to determine the situations of the principal points on the sea coast, and those objects which are near it. Having executed this resolution, the result will sufficiently explain its importance; as it will be found, that by the intersections of churches, or other edifices, the coast is laid down from Fairlight Head to Portland. Thus, Bexhill Church, Pevensey Church, the station on Beachy Head, Brighthelmstone Church, Southwick Church, New Shoreham Church, Goring Church, Pagham Church, Selsea Church, Selsea High House, Cackham Tower, and the Watch House at the mouth of Chichester Harbour, mark the coast of Sussex. In like manner, it will be found, that the coast of Hampshire is laid down from the intersections of many remarkable objects, of which the principal ones, are South Hayling Church, Portsmouth Church, Calshot Castle, East Cowes Sea Mark, St. Catherine's Light House or Sea Mark, Ashey Down Sea Mark, the Needles Light House, Hurst Castle Light House, with Christchurch Head, or, as it is more frequently called, Hengistbury Head. The coast of Dorsetshire also, has many places laid down:—Poole Church, Branksea Castle, the Barrow on Swyre Head near St. Albans

Head, and Wyke Church near Weymouth. Those are some of the principal objects which mark the coast, being very near it.

Upon the commencement of the present business, the design was to divide it into two parts; namely, one for ascertaining distances from the triangles, whose angles were to be observed with the large theodolite; and the other, the interior survey of the country, in which a small instrument, made upon the same plan with the great one, was intended to be used. This instrument being now nearly finished, that design will be carried into execution; and as two or three hundred *single* bearings have been taken from the different stations, which cannot at present be made use of, an important addition will be made to the number of places already fixed, independent of others, whose situations will be determined with it, in the course of the survey. The result of this, as well as the other parts of the trigonometrical operation, will be given to the public, in the Philosophical Transactions. And should it be discovered, from the use of the small instrument, that any of the secondary triangles are erroneous, such errors will be corrected, as well as any *errata* which we may find in this account.

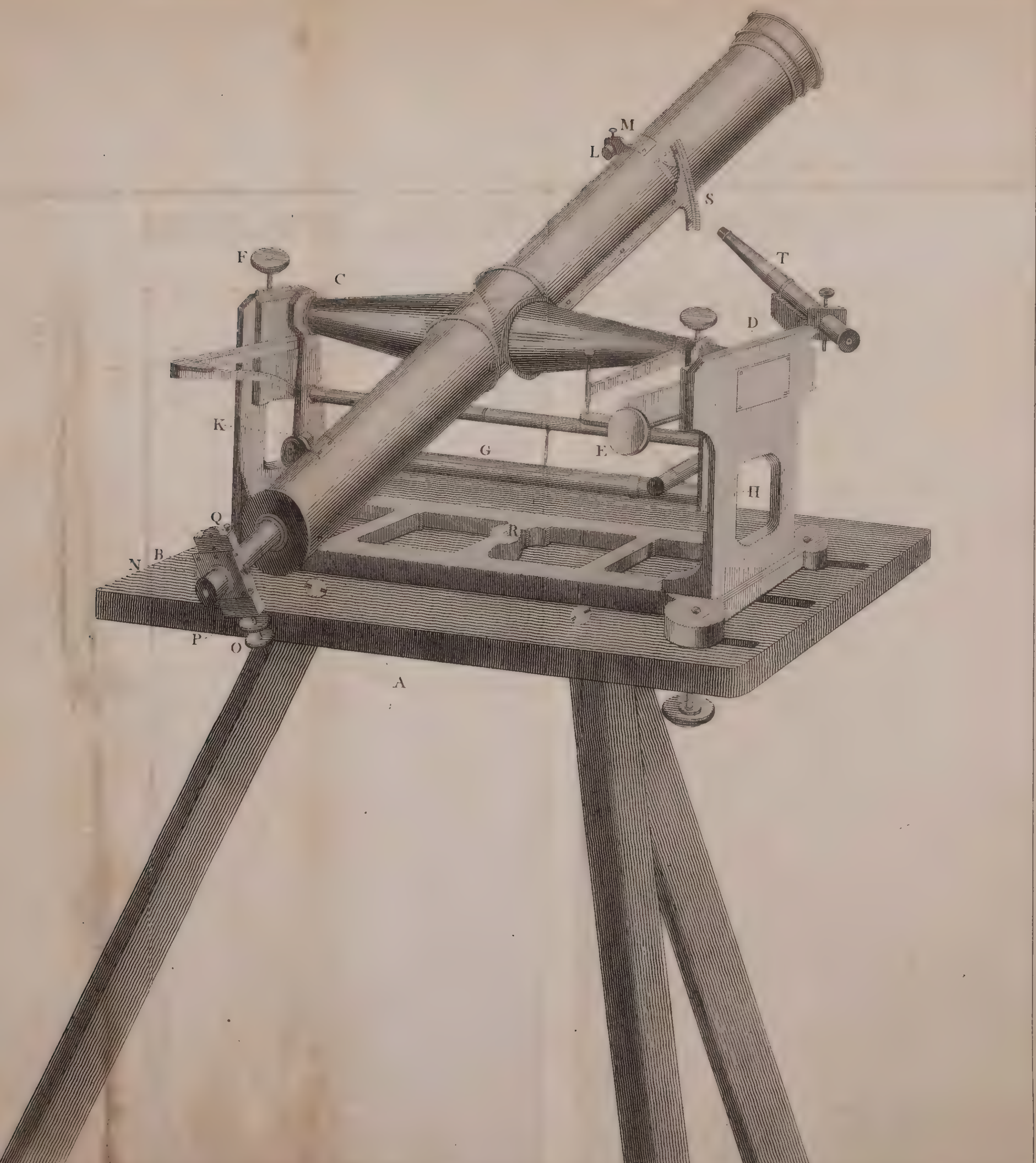
From the instructions given to those who have the honour to be employed in this undertaking, namely, to consider the survey of the sea coast, in the first stage of the business, their principal object, the design is to carry on a series of triangles to the Land's End. For that purpose, there are already five new stations selected; two in the Isle of Portland; one on Charton Common, near Lyme; another on Pilsden Hill, near Broad Windsor, and the other on a hill near Mintern; all in Dorset-

shire. How those stations connect with each other, will be easily seen, on having recourse to a map. The distances between the stations in Portland, and that on Charton Common, will serve as bases for fixing the points on the coast of Devonshire, and the side Charton Common and Pilsden Hill will connect with the high land near Honiton.

N.B. In the plan of the triangles (Tab. XLVI.), the line from the station near the Four Mile-stone to Old Sarum, is drawn a little out of its true position, otherwise it would very nearly coincide with that which joins the former station and Dean Hill.

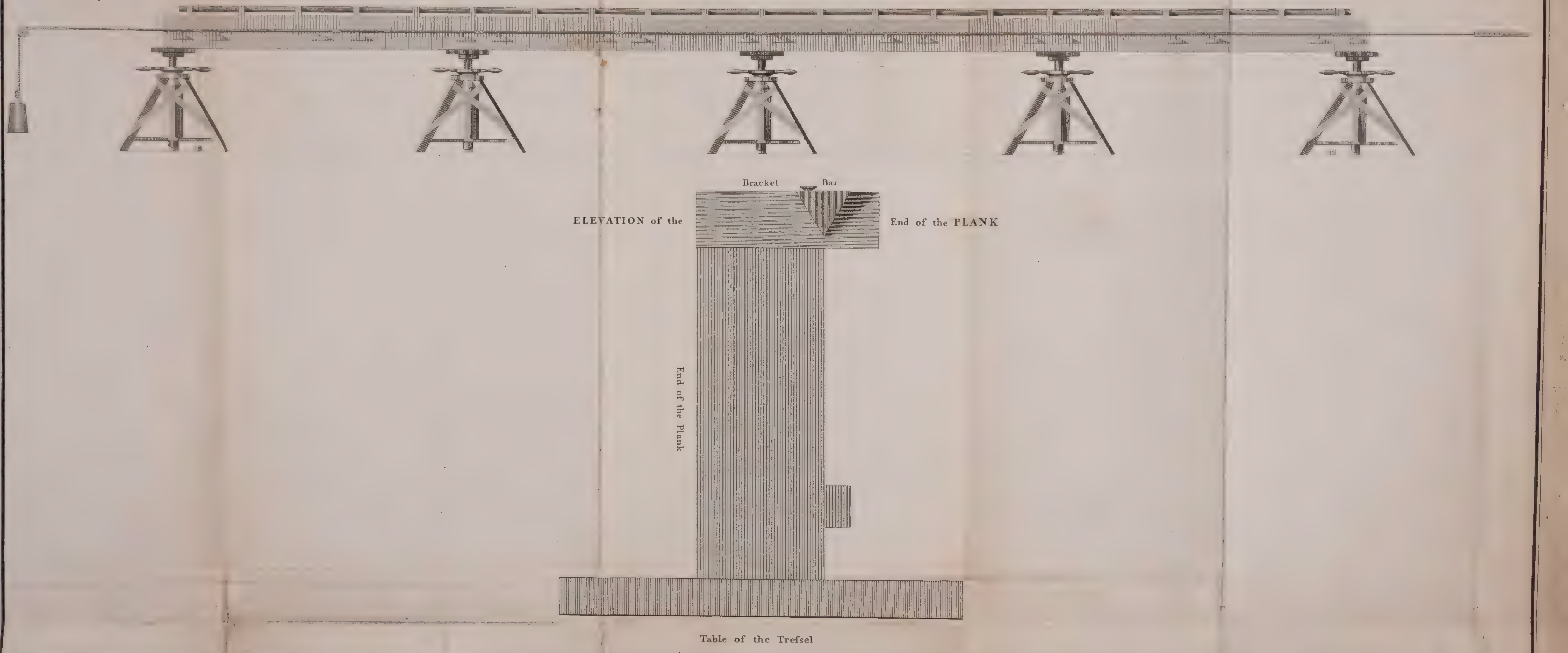
PORTABLE TRANSIT INSTRUMENT.

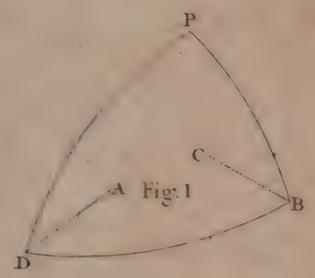
Philos. Trans. MDCCXCV. Tab. XLIII. p. 592.

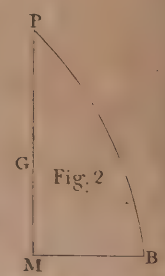


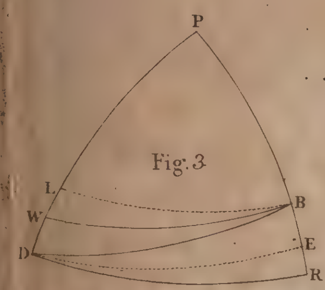
John Warner del. et sculp.

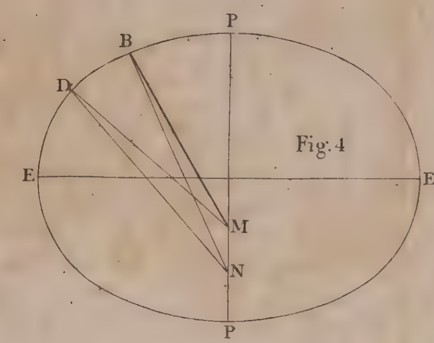
ELEVATION of the PLANK and BAR used in determining the lengths of the CHAINS

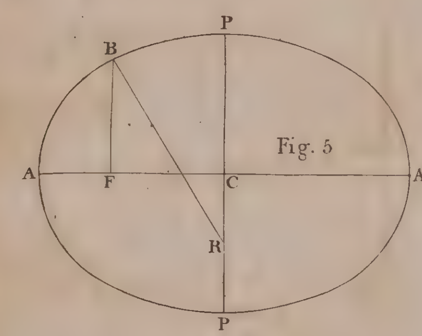




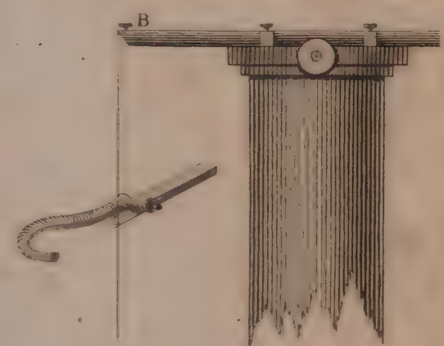








Wire and Handle of the Chain.



A PLAN *of the* PRINCIPAL TRIANGLES *in the* TRIGONOMETRICAL SURVEY, 1791 — 1794.